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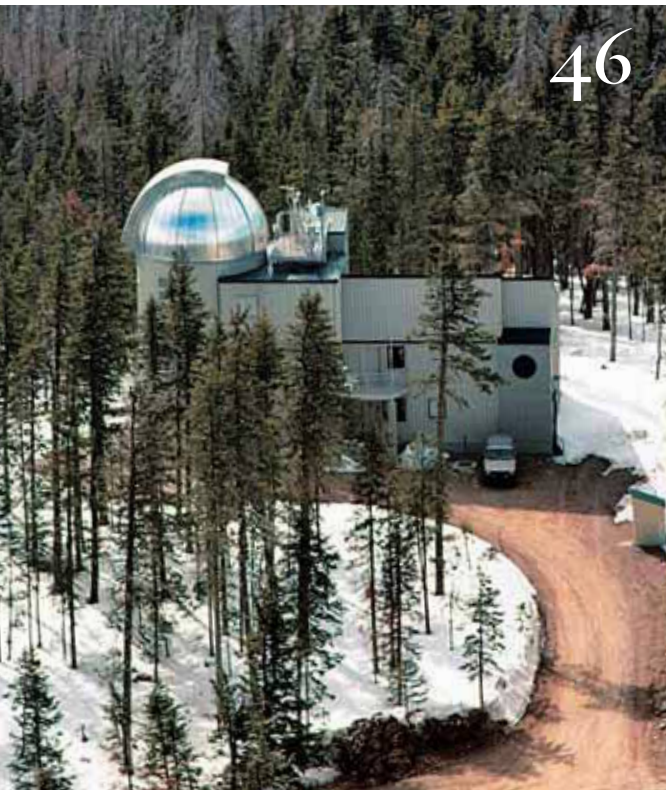


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WOLFGANG PROMPER

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### ON-LINE EXTRAS THIS MONTH:

DESCENDANTS OF THE DIPPER: Find out which stars belong to the Ursa Major moving group.

EXPLORE THE SPRING SKY: Challenge yourself to locate some of the season's fainter objects.

SEARCH FOR SPACE ROCKS: Use the Star Dome to plot the locations of 20 bright asteroids.

STRIKING ANCIENT SKIES: Learn how to start collecting ancient astronomical coins.

INTERVIEW: Read an excerpt from Neil deGrasse Tyson's memoir, *The Sky is Not the Limit*.

### ON THE COVER

In the mysterious SS 433, a high-mass object (possibly a black hole) strips gas from a companion star. The gas forms a swirling disk before it disappears forever, sucked into the high-mass object. Two energetic jets radiate from the disk's center at such high speeds, one (toward us) is blueshifted and the other (going away) is redshifted. ADOLF SCHALLER/OMNICOSM STUDIOS


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BY DAVID J. EICHER

# Meet the Vatican's astronomer

## For the past 27 years, a remarkable man has kept his eyes trained on the heavens from a special place on Earth. Father George Coyne has led the Vatican Observatory in a relentless pursuit of science from Castel Gandolfo, the pope's summer residence in the Alban Hills, southeast of Rome. This past summer, members of the

*Astronomy* staff interviewed the Jesuit priest over lunch. The resulting article, "Coyne of the realm" (page 46), was assembled by associate editor Francis Reddy. The story provides an intimate look at the relationship between faith and science.

Why is the Catholic Church doing astronomy? This question arises frequently for Coyne — and it betrays a poor appreciation of history, as the Jesuit tradition of observing nature led to the founding of the Vatican Observatory in 1891.

Coyne's tenure as Vatican Observatory director has seen explosive growth: Under this mild-mannered man from Baltimore, the institution undertook construction of the Vatican Advanced Technology Telescope (VATT) on Mt. Graham, Arizona. Completed in 1993, the VATT is one of the most powerful research telescopes in the world. It also serves as a test bed for the Large Binocular Telescope, which will stand a few hundred feet away.

Coyne receives many questions from scientists and the public about the observatory's activities. But he receives far more queries about the relationship between faith and science. Isn't there an inherent train wreck where the two subjects meet? There's not for Coyne, who received his Ph.D. from Georgetown University in 1962 and became an ordained Roman Catholic priest 3 years later. "In a sense, they are two different compartments of my life," says the astronomer, now 71. "Knowing more about the universe and believing that God created the universe, nourished my knowledge of the spiritual background."

ASTRONOMY: WILLIAM ZUBACK

FATHER GEORGE COYNE visited with Dave Eicher (left) and the *Astronomy* staff in Milwaukee.

Coyne's research interests have included polarimetric studies of the interstellar medium, Seyfert galaxies, and stars with atmospheres. He has also studied polarized light from cataclysmic variable stars, binary systems that emit sudden bursts of energy.

To Coyne, humanity transcends purely scientific thought. "I believe God is creator," he says, "and I've never come to that belief through any purely rational process. It's not irrational — I don't think it contradicts reason — but it transcends reason."

Yours truly,

David J. Eicher
Editor


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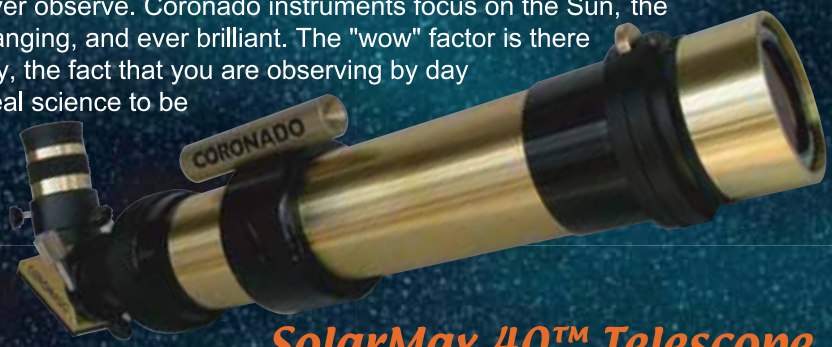


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| Optical Design | Maksutov-Cassegrain | Maksutov-Cassegrain | Maksutov-Cassegrain |
| Focal Ratio | f/13.8 | f/14 | f/15 |
| Focal Length | 1250mm | 1470mm | 1900mm |
| AutoStar | #497 | #497 | #497 |
| Field Tripod #884 | Included | Included | Included |
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### POINTING & TRACKING ACCURACY

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"They make it easy for beginners to explore the sky and grant experienced observers more time looking at objects than hunting them.... Having AutoStar at my fingertips easily tripled the number of targets I viewed in the space of a few hours. A key feature for experienced observers, you can observe more targets in a given time." ***– Astronomy Magazine***

### ASTROPHOTOGRAPHY

"With a strong background in astrophotography, I was particularly interested to see if the LX90 would live up to its claims. The short answer? It certainly does, and then some." ***– Sky & Telescope Magazine***

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- High Precision Internal Clock
- Red Dot Viewfinder (SmartFinder™)

LNT LEVEL NORTH™ TECHNOLOGY

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| Optical Design | Schmidt-Cassegrain |
| Focal Length | 2000mm |
| Viewfinder | 8x50 Optical & LNT Red Dot |
| AutoStar | #497 |
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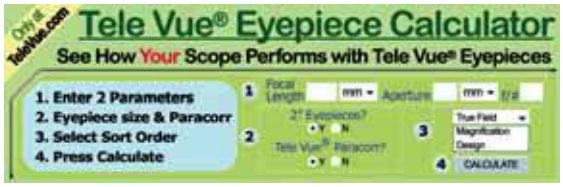


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# Stargazing in Iraq

Thank you for the interesting article, "Wartime astronomy" (December 2004) by Matthew Quandt, which records the experiences of Iraqi amateur astronomer Ra'ad Ali Abdul Aziz. The piece describes how it takes wars to make the night sky visible in Iraq. Clearly, astronomers around the world need a better way of reducing light pollution. Is there any progress on this issue, or is it a lost cause? — NICK LEGGETT, RESTON, VIRGINIA

*Astronomy* arrives at our home because my son has a subscription. He is a freshman in college and lives 4 hours away, so I've been sending him *Astronomy* in a care-package each month. Usually, I don't have time to read the magazine, but the title "Wartime astronomy" caught my eye.

Am I glad I read it! Matthew Quandt did an excellent job weaving the story of Ra'ad Ali Abdul Aziz and his stargazing over many years and giving the readers historical details about Iraq. I hope Ra'ad is indeed safe amidst the horrors of war. — DIANA RANDOLPH, DRUMMOND, WISCONSIN

*Three weeks after being abducted at gunpoint from their offices in Baghdad, Iraqi aid workers Ra'ad Ali Abdul Aziz and Mahnaz Bassam, together with Italian aid workers Simona Pari and Simona Toretta, were released unharmed. Their captors' identities remain unknown.*

*Ra'ad remained in Baghdad during times of war to "help the people here and to show for myself that we can build, we can celebrate the universe." Sorrowfully, he recently left Iraq and moved to Switzerland with his wife and son.*

*"We faced death during 3 weeks as hostages from the same people that we helped," he says. He hopes to find a civil engineering job in Europe — "far away" from the lifetime of turmoil he's endured.* — MATTHEW QUANDT, ASSISTANT EDITOR

RA'AD ALI ABDUL AZIZ moved to Switzerland after being kidnapped in his native Iraq. VITW

## Astrology exposed

"Astrology: fact or fiction?" by Michael E. Bakich (December 2004) had a number of historical and other goodies I enjoyed.

In 1945, I was called for active duty along with a number of other 18-year-olds who had enlisted in the U.S. Army Air Force from 11 western states — strictly by birthday. I ended up in basic training in a "flight" with 30 other would-be pilots born within a few days of me, several on the same date. That is, we were all born under the same sign, with the stars and planets virtually the same for all of us.

According to astrology, we all should have had similar personalities, but you can imagine what the real situation was: We were as diverse a bunch as ever existed. An astrologer might say it's the exact moment of birth that counts, and that must have differed among us. But if that's the case, newspaper horoscopes must be worthless! — FRANK B. SALISBURY, SALT LAKE CITY

I enjoyed the December article about astrology. I have a friend who is obsessed with the subject, but I was never a big fan. What was written in that piece just confirmed my doubts! — JOHN POLAND, MANCHESTER, CONNECTICUT

## Understanding the Moon

I have been fascinated by the Moon my entire life, and Bob Berman's December 2004 article, "Moon orbit oddities," is the first good explanation of its behavior I have read. I now have a new understanding of it. — ROD HORNER, MANITO, ILLINOIS

## Preparation is key

"Killer impact" (December 2004) may well be a timely warning. An asteroid impact may have similarities with or trigger other disasters such as nuclear warfare, earthquakes, or volcanoes. So, preparation for an adequate response to any of these could aid in responses to similar calamities.

Consequences of such disasters, such as dust in the atmosphere causing climactic cooling, toxic substances released in the atmosphere, and massive loss of population and infrastructure, are some potential problems of major concern. — GARY VARDON, WEST VALLEY CITY, UTAH

## Correction

The web address for Andrew Fraknoi's "Astrology Defense Kit" was incomplete in the December 2004 Resources. The correct site is *www.astrosociety.org/education/astro/act3/astrology3.html*. — *ASTRONOMY* EDITORS

*We welcome your comments. Send letters to* Astronomy *Letters, P.O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

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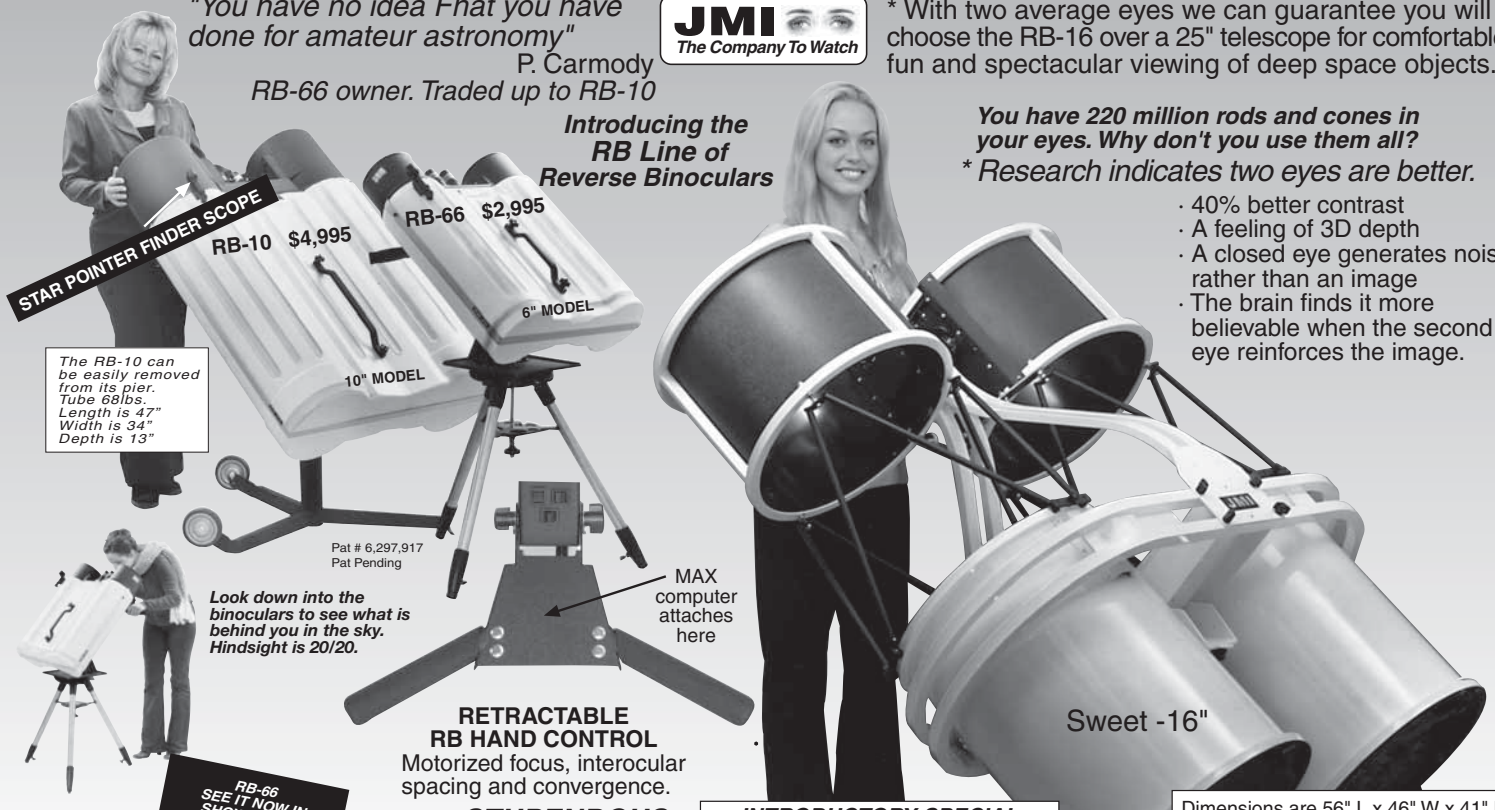
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BY BOB BERMAN

# Annihilate this

## If antimatter didn't exist, someone

would have to make it up — it's that juicy. Predicted by the brilliant physicist Paul Dirac in 1928 — and first found by Carl D. Anderson of Caltech in 1935 — antimatter looks, smells, and acts exactly like ordinary matter. But let it touch anything, and both vanish in a maximum-energy explosion.

It's easy to understand, because antimatter's the same as regular matter, except all electrical charges are reversed. It's as if some incompetent deity from another dimension accidentally wired it backwards. At the center of anti-atoms lurk antiprotons with negative instead of positive charges. Positive electrons — positrons — orbit the antiprotons.

When the most recent incarnation of the universe was born 13.7 billion years ago, equal amounts of matter and antimatter should have been created. Collisions happened all the time in that crowded, wild environment, and when the dust settled, everything should have evened out. It didn't. Somehow, we ended up in a matter-dominated universe. Theorists still debate why that happened. Recent evidence suggests nature has a slight bias for matter instead of antimatter creation — that the two processes are not as symmetric as everyone thought.

Nevertheless, the cosmos could contain entire antimatter stars. The light emitted by such antisuns would be identical to the energy from normal stars. Looking into the night sky, there's no way to know whether a star is matter or antimatter.

There could be antimatter planets, too. Maybe there's an anti-Earth, with anti-restaurants serving antipasto. There might even be an anti-me and an anti-you. Unlike the Earth-you, the anti-you neatly folds his clothes at night instead of tossing them on the floor.

The most dramatic thing about antimatter is what happens when it encounters ordinary materials. Remember $E=mc^2$? Write down the weight of anything (in grams), multiply that by the square of lightspeed expressed in centimeters per second (roughly 30 billion times 30 billion) and *voilà*: That's how much energy (in ergs) is in that lump of material. Every cigarette butt on the street is a cauldron of super-energy trapped in a dormant, disgusting form. Release it, and you could power your house for a thousand years. Well, your subwoofer anyway.

H-bombs and the solar core unleash energy with only a 0.007 efficiency. Seven-tenths of one percent. But when matter and antimatter meet, their masses convert to energy with 100 percent efficiency. And you could use anything at all — junk mail, corpses — any matter works.

But where to get the antimatter? Nobody's selling any, not even on eBay. It's made in particle accelerators like Fermilab, but it's not cheap. Current annual global production is about 10 nanograms (billionths of a gram). The biggest chunks are whole anti-atoms, first created in 1995.

It's hard to keep, too. Antimatter would annihilate the wall of any container you put it in. Like leftover Chinese food, the best storage solution is to keep it in a vacuum in the fridge. If chilled near absolute zero, it would scarcely move around. Then, if you manufactured only charged positrons or antiprotons, the antimatter could be suspended in a magnetic field.

A moving field, like those that levitate bullet trains, could guide such fuel to a rocket's combustion chamber to meet bits of regular matter.

Such magnetic containment is the way to go, but you'd better be sure the field never wavers due to a power failure or technical problem. ("We're losing containment!" shouted Scotty. The crew knew this wasn't just a minor problem for the *Enterprise*'s to-do list. "Lost containment" meant the ship and crew would turn into pure energy, voiding their insurance.)

> { Unlike the Earth-you, the anti-you neatly folds his clothes at night instead of tossing them on the floor.

We know antimatter is out there because matter-antimatter annihilation produces photons with a recognizable signature of 511,000 electron volts. Geysers of such positronic debris erupt violently from our galaxy's core, at right angles to the Milky Way's plane.

Although these blazing fountains were discovered by the Compton Gamma Ray Observatory 8 years ago, their source is still a mystery. Massive star bursts? Black-hole antimatter factories? Nobody knows the origin of the Milky Way's antimatter.

Someday, antimatter may help propel us to the galaxy's core to see for ourselves. Odds are, the trip won't be anticlimactic. A

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New experiments at the Laser Interferometer Gravitational Wave Observatory (LIGO) in the US and the GEO 600 gravitational wave observatory in Germany could begin detecting gravitational waves this year, opening up a whole new window on the universe. The experiments measure minuscule changes in the paths of laser beams – detecting gravitational-wave induced distortions as small as one part in $10^{22}$.

Amateur astronomers and science enthusiasts now have an unprecedented opportunity to aid in the emerging field of gravitational astronomy through the Einstein@Home distributed computing project, brought to you by the World Year of Physics 2005.

Anyone with a personal computer (including Windows, Mac, or Linux-based systems) can sign up to contribute some of their computer's idle time to the detection of gravitational signals in a whole-sky search for spinning, aspherical, neutron stars. Participants install a screensaver-based program, which downloads and analyzes small segments of experimental data. During the computer's idle cycles, the screensaver displays an image of the rotating celestial sphere, highlighting where it is currently searching for a signal.

Einstein@Home is real science at the grassroots level, and it's free! If a signal is found it will be a groundbreaking discovery. We need your help to make this historic research project a success.

Visit www.physics2005.org/events/einsteinathome to find out about Einstein@Home and how you can be among the first to search for Einstein's gravitational waves.

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BY GLENN CHAPLE

# Jealous Copernicus

## Circle Friday, March 11 on your *Deep Space Mysteries 2005* calendar. On that date, you'll have a great opportunity to do something even the famous Polish astronomer Nicolaus Copernicus never did: visually capture the elusive planet Mercury. Even during elongations — those infrequent occasions when the planet's orbital motion

carries it away from the Sun — Mercury can play hard-to-get in the twilight glow. But March 11, a 1.5-day-old crescent Moon will help point the way. A half hour after sunset, look for the Moon's razor-thin crescent about 15° above the western horizon (binoculars will help). Once you've spotted the Moon, direct your gaze 8 Moon diameters down and to the right. That bright yellowish "star" is Mercury.

If you're the adventurous type and think you can get by without the Moon's help, start your Mercury quest around the beginning of March. Mercury will be visible throughout the first 3 weeks of March, with optimum visibility around greatest eastern elongation March 12.

### Copernicus missed out

Is it true Copernicus never saw Mercury? After mentioning the Copernicus-Mercury legend in this column 2 years ago ("Mercurial sightings," April 2003), I received a letter from noted British astronomy-writer Sir Patrick Moore. He wrote that, during a visit to Copernicus' hometown of Torun, Poland, in 1973, he viewed Mercury on 6 consecutive evenings — even through the city's light-polluted skies.

The inference was that Copernicus would have had little trouble spotting the planet. Unfortunately, Copernicus isn't around to settle the question. But his writing may provide some insight.

While working on his Sun-centered model of the solar system, Copernicus attempted to calculate the planets' orbits. This task requires observations of their positions in the night sky. By his own account, he was unable to see Mercury because of the "vapours" (fog) that enshrouded the nearby Vistula River.

NICOLAUS COPERNICUS reportedly never enjoyed a view like this of Mercury (small object left of center) from his home. JOHN E. STONE

Still, it's hard to imagine this celebrated astronomer failed to see Mercury — especially during his extensive travels throughout Europe. The whole matter reminds me there's more to astronomy than probing the night sky with a telescope. It's also about exploring the rich and fascinating history of the oldest science.

### Moon targets

After its encounter with Mercury, the Moon continues a steep nightly climb in the western sky. If you point a telescope moonward the evening of March 16, your gaze will be drawn to a striking row of three craters near the terminator — the border between the Moon's dark and bright sides. All three craters are 62–65 miles (100–105 kilometers) in diameter (big enough to hold the state of Rhode Island), but that's where the similarity ends. Theophilus, the deepest of the three (about 13,000 feet, or 4,000 meters) and most recently formed, has a pronounced central peak. The other two, Cyrillus and Catharina, are shallower and more ancient.

When viewing the Moon with a telescope, start with low magnification (25–50x) to locate your area of interest, then switch to 100x for a better view. If it's cloudy and you can't see the Moon, log on to the Lunar Navigator at *www.lunarrepublic.com/atlas/index.shtml*. You'll find an interactive map that identifies some 2,500 lunar features.

### Messier marathon time

Last year, I challenged fellow *Astronomy* writer Phil Harrington to a Messier marathon (March 2004). My trash-talking was for naught, as cloudy skies here in the northeast United States shut us down. Although this event (an attempt to observe as many of the 100-plus deep-space objects in the Messier Catalog as possible in a single night) can be run anytime, it's during March that the Sun hides the fewest Messier objects. The best opportunity occurs annually around March 21, but this year, a waxing gibbous Moon will spoil things. I'm planning my Messier marathon for the moonless weekend of March 11.

Try your luck locating some of the brighter Messier objects plotted on our all-sky map on page 55.

Get your telescope ready, Phil. You're going down!

Next month: We explore Gemini the *Triplets*. If you thought Gemini represented the heavenly Twins, stay tuned for a pleasant surprise! Clear skies.

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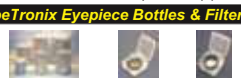
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BY WILLIAM SCHOMAKER

# Neil deGrasse Tyson

## The Big Apple and Neil deGrasse Tyson

go way back. Born and raised in New York City and an alumnus of the Bronx High School of Science, Tyson credits a visit to New York's venerable Hayden Planetarium when he was 9 with introducing him to the universe. This visit inspired him to obtain a Ph.D. in astrophysics. Now, he is an astrophysicist with the American Museum of Natural History and is the Frederick P. Rose director of the Hayden Planetarium. Tyson is hailed as one of the most accomplished scientists and communicators of his generation.

He's played a pivotal role as a two-time commission advisor to the White House on aerospace and space-exploration policy; authored seven books, including his memoir, *The Sky is Not the Limit: Adventures of an Urban Astrophysicist*; and made numerous television appearances as an astronomy commentator.

### When did you commit to public outreach and promoting scientific literacy?

One day, before eighth-grade Algebra II class began, a classmate was at the chalkboard trying to review a homework assignment with a (straight-A) classmate, who was doing all the explaining. When the explanation was not going well, I jumped in to try my hand. My understanding of the mathematics was so clear in my head that telling others about it was no different from recounting what I had for dinner the night before.

I learned at that moment that knowing something is a necessary, but not sufficient, condition for helping others. You also need to know what could be going on in the minds of those you are communicating with, for therein lies the conduit of communication, rather than the one-way street of a lecture. I have been explaining things ever since.

NEIL DEGRASSE TYSON devotes as much time and energy as he can to promoting astrophysics. CUTTY McGILL

### Are you satisfied with the state of scientific literacy in America?

I am not as concerned about low scientific literacy as I am about the absence of critical thinking [in] America. Our school system will have you believe you are an educated person for what you have learned by the time you graduate. But what you *know* is not as important as how you *think*. People with critical-thinking skills can solve problems they have never seen before.

### How can we teach people to distinguish between science and pseudoscience?

The claims and tenets of real science, even when the concepts sound outlandish, are traceable to a consensus of experimental results. Pseudoscience never enjoys such support. So, the capacity to evaluate evidence is crucial.

Most important is one's awareness of how unreliable eyewitness testimony really is. In pseudoscience, you get claims like: "I saw a flying saucer with aliens inside," or "I saw the Loch Ness monster."

These statements instead need to become: "Here is a device I stole from the aliens aboard the flying saucer. Please analyze it in the laboratory," or "I have a sample of flesh from Nessie. Please analyze its DNA."

The frontier of science is, of course, only poorly supported by data. Indeed, that's what defines the frontier of science. Were you to eavesdrop there, you would hear scientists argue about what is true and invoke their highest levels of skepticism on the claims of their colleagues.

This [debate between scientists] continues until the data — not the loudness or earnestness of one's claims — establish a truth beyond doubt, thereby advancing the frontier a bit further. So, every year in school, from kindergarten into college, there ought to be time devoted in class to the evaluation of evidence.

### What advice do you have for parents who want to help their children achieve their wildest dreams?

Get out of the way.

Kids are born investigators of the natural world around them. Nurture that, even if it means the kids will make a mess in the kitchen, or make incessant noise hitting pots and pans, or exhibiting what might seem like unruly behavior.

If it is done in the name of experiment, the long-term benefits outweigh the short-term hassles of the cleanup and the noise.

An excerpt from Tyson's memoir appears at www.astronomy.com/toc

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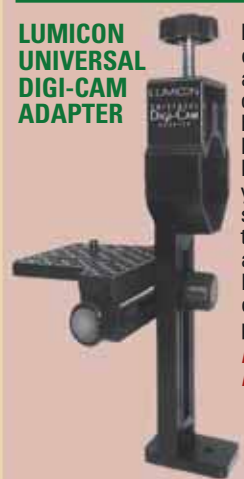

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# news 03

Read all about it: the youngest Moon rock, launching satellites on old Russian ICBMs, a pulsar that's way too cool, and a Kuiper Belt object with a face-lift.

STAR-MAKING KIT. This image of the Tarantula Nebula, a giant stellar birthplace, was assembled by an amateur astronomer using HST photos. ESA/NASA, ESO, D. LaCRUE

24 Helix Nebula: not built like a bagel
26 Dusty disks and stars
28 How nature made Mars so rusty
30 Newly found star in the Sun's neighborhood

HUBBLE SPACE TELESCOPE

## Amateur astronomer images nebula with HST

Danny LaCrue, an amateur astronomer from southern California, assembled a stunning panorama of the central Tarantula Nebula using free software, 15 archived Hubble Space Telescope (HST) images, and spare time.

"At first, the imaging archive was somewhat intimidating to navigate," says LaCrue, 23. "But after a few object queries and requests for data, the whole process became much less daunting." He chose the Tarantula, he says, because he found a lot of material on the nebula.

The Tarantula, a rich star-making region, lies in the Large Magellanic Cloud, some 170,000 light-years from Earth. The nebula has drawn the gaze of Hubble-using astronomers for years, and the HST archives contain more than 1,000 images and spectra of the nebula. The software LaCrue used, *FITS Liberator*, is a plug-in for Adobe *Photoshop* (full version and *Photoshop Elements*) and is free at *www.spacetelescope.org/projects/fits_liberator*.

For those attempting this for the first time, LaCrue advises, "It's not as hard as it sounds, but you do need patience." Lots of computer memory helps, too. Says LaCrue, "I use a regular IBM-type computer with a gigabyte of RAM. And high-speed Internet access really helps with the large image files." — ROBERT BURNHAM

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NO PATCH KIT? NASA engineers working on returning the space shuttles to flight have decided that the first shuttle to fly, probably in late May, could launch without a tested patch kit to fix any damage in flight.

ASTROPHYSICS

# Super-cool pulsar

Astronomers using the Chandra X-ray Observatory have taken the temperature of the pulsar in 3C 58, the remnant of a star that exploded as a supernova in A.D. 1181.

The pulsar is a spinning, magnetized neutron star, the collapsed core of the exploded star. Chandra observed the complex interplay between the pulsar, its beams of fast-moving particles, and the hot gas enveloping the remnant.

What surprised astronomers, though, is how cool this neutron star turned out to be.

"We now have strong evidence that, in slightly more than 800 years, the surface of the 3C 58 pulsar has cooled to a temperature of slightly less than a million degrees Celsius," says Patrick Slane (Harvard-Smithsonian Center for Astrophysics). Slane is the lead author on a paper describing the study that appeared in *The Astrophysical Journal* (November 20, 2004).

"A million degrees may sound pretty hot," notes Slane, "but for a young neutron star, that's like the frozen tundra in Green Bay, Wisconsin."

How fast pulsars cool depends strongly on the physical conditions within neutron stars. Created in unimaginable violence, 3C 58 and other young neutron stars are hinting to astrophysicists that something unknown is squelching their birth heat. — FRANCIS REDDY

COOL PULSAR. Chandra's view of 3C 58 is merged with an image of the same region in visible light (gold). Bluer colors indicate higher X-ray energy. MCGRAW-HILL/NASA/CXC/SAO/P. SLANE ET AL./F. REDDY

BIG BLUE EYE. Seen from the side, the Helix Nebula would show two intersecting disks. ARTWORK: NASA/ESA/G. BROWN

PLANETARY NEBULAE

## Not like a bagel...

"A year ago, we believed the Helix Nebula was a bagel shape, filled in the middle," says C. Robert O'Dell (Vanderbilt University), head of a team that studied the nebula with the Hubble Space Telescope and ground telescopes.

A new view sees it as two intersecting rings. One is the familiar Helix (reddish tints, above), while the other meets this at almost a right angle.

Astronomers are left guessing what created the second ring. Perhaps the nebula's central star has a companion; if so, one ring might lie in its orbital plane while the other circles the central star's equator. — R. B.

PLANETARY SCIENCE

## Big KBO got a face-lift

Quaoar, a large, icy body in the Kuiper Belt, shows a surprisingly young face hinting at volcanic activity, say planetary scientists David Jewitt (University of Hawaii) and Jane Luu (MIT).

In *Nature* (December 8, 2004), they report finding ammonia hydrate there and a form of water ice that has been warmed.

"The solar wind and charged particles would destroy the ammonia and crystalline ice in about 10 million years," says Jewitt. "This implies that Quaoar gets recoated on that time scale or faster."

Two face-lift scenarios appear the most likely. Radioactive heat warms ice inside Quaoar and impacts then strew it across the surface.

Or, says Jewitt, "buried ice gets blown out of the interior by gas, in a kind of cryovolcanic burp." — R. B.

COLD GOO. Quaoar's surface, rich in organic elements, has a geologically new look. ARTWORK: STScI, G. BROWN

PLANETARY SCIENCE

# Youngest Moon rock found

A piece of breccia from the Moon found in Africa has the youngest date known for a lunar rock: 2.865 billion years. This is several hundred million years younger than any mare basalt and about a billion years younger than any lunar rock of its kind.

LUNAR YOUNGSTER. A Moon meteorite, probably from near Oceanus Procellarum, has an age about half of Earth's. SOUTHWEST METEORITE LAB, M. KILLGORE

The baseball-size meteorite, Northwest Africa 773 (NWA 773), contains breccia, rock fragments welded by impact. The largest chunk, though, is olivine gabbro, analyzed by a team under Lars Borg (University of New Mexico).

"We found that NWA 773 has the youngest crystallization age for any lunar material," says Borg. The Moon may have younger rocks, he notes, but they have not yet been found.

"We've got material from all over the Moon," says Borg, "but we don't see any with very young crystallization ages. Our sample collections could have young materials, but we don't recognize them — or perhaps they're just not there." — R. B.

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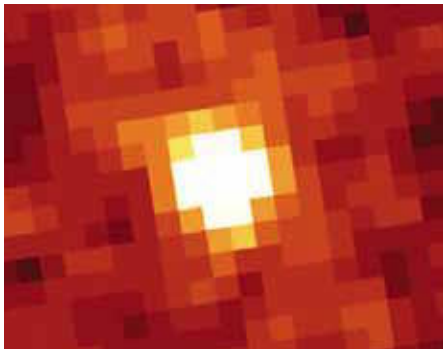

WARM SPOT. A hundred light-years from Earth, warm dust surrounds star HD 50554, which is about as old as the Sun. This dust disk resembles the Sun's Kuiper Belt. NASA/JPL-CALTECH, C. BEICHMAN

STELLAR ASTRONOMY

## Stars and the dusty disks around them

The Hubble and Spitzer Space telescopes have imaged dusty disks around stars within 100 light-years of Earth. Charles Beichman (Caltech) says Spitzer saw excess infrared radiation in six star systems known to have planets.

"These systems," he says, "have 2 to 15 times more heat than we expect from just the stars." He added that the excess could come from a disk of dust and debris similar to the Sun's Kuiper Belt.

Alycia Weinberger (Carnegie Institution of Washington) says, "Prior to these observations, we didn't know of any systems other than our own that harbored both planets and disks. The Spitzer images close the loop — they show us both the planets and the disk."

Working with Hubble, David Ardila (Johns Hopkins University) found disks of cool debris around the stars AU Microscopii and HD 107146. AU Mic's disk is about 4 times the size of our solar system, while HD 107146's disk is 3 times the solar system's diameter. Both stars are much younger than the Sun.

"These systems will provide very exciting targets for future NASA missions," says Weinberger. "The Terrestrial Planet Finder will certainly be able to see the disks and to resolve them and tell us about their structure." — MICHAEL E. BAKICH

## Turning swords into space plowshares

Converted military missiles have launched satellites since the Space Age began. But Russia has announced a novel plan to use its obsolete intercontinental ballistic missiles (ICBM) for space shots. Instead of being hauled away to a specialized launch range, the missiles will be fired directly out of their underground combat silos.

Russia's SS-18 heavy missile (NATO code name: Satan) was built to throw multiple thermonuclear warheads against the United States. Many of them remain on combat alert at four bases east of the Ural Mountains. As the two-stage, liquid-fueled rockets age, however, they are taken off active duty.

A Russian company, Kosmotras, has been selling SS-18 missiles (four since 1999) for commercial space launches. The company added an upper stage, giving it greater power, and renamed it Dnepr (after the Russian river), a far more business-friendly name.

The SS-18s launched so far were transported to the Baykonur cosmodrome in Kazakhstan, where technicians installed a small third stage, allowing the rocket to reach higher orbits. An improved third stage is in the works, and by 2007, it will allow the modified missile to send payloads up to about 1,000 pounds (450 kilograms) on interplanetary trajectories. Costs should run far lower than for other commercial launchers.

Most of the prospective business, however, lies in Earth satellites, and to take advantage of this, Kosmotras is altering the way it launches the Dnepr. In the near future, the missiles will blast off from the military base at Dombarovskiy, east of Orenburg in the Ural Mountains.

Instead of heading for North America, however, the rockets will fly south, with a slight turn to the right. The resulting orbit is Sun-synchronous, meaning it always passes over the same sites on the ground at approximately the same times of day.

OFF TO WORK. Renamed and refurbished, Russian ICBMs will launch commercial payloads directly from their old silos. KOSMOTRAS

Such orbits are widely used by Earth-observation satellites and occasionally by science satellites needing to keep the Sun in view continuously. The orbits are often difficult to reach from existing rocket launch bases, which were situated originally with clear tracks to the east (the best direction for exploiting Earth's spin for an added launch boost). Often, as with Cape Canaveral, Russia's Plesetsk, and other major launch sites, the ground track leading to Sun-synchronous orbit passes over populated regions and is ruled out for safety reasons.

Dombarovskiy, however, borders on Kazakhstan, and the path to the south passes mostly over open desert. So, quite by chance, the launch site was built decades ago in a location that is now proving convenient for orbital inclinations that weren't even understood when the concrete was poured. And the mission it was built for under the Soviet Union has vanished, so a new mission involving space science and commercial applications is now appropriate. — JAMES OBERG

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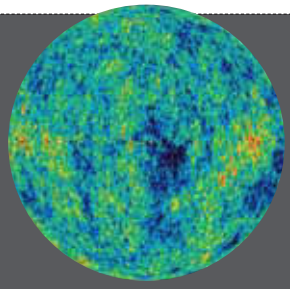
**MARS FIELD GEAR.** NASA has selected eight experiments to fly aboard the Mars Science Laboratory, a large, wide-ranging rover due to launch in 2009. The experiments include a radiation sensor to test risks to astronauts.

## The winds of Aeolis

**UPSIDE-DOWN LANDSCAPE.** Wind erosion "inverted" the relief in this part of Aeolis on Mars. Old stream beds, choked with debris and standing high as ridges, snake across linear hills carved by the wind. The image, sunlit from the upper left, is about 1.9 miles (3 km) across. NASA/JPL/MSSS/IMAGE R17–00952



BIG BANG ECHO. The cosmic microwave background has unexplained warm and cool spots. NASA/WMAP MISSION

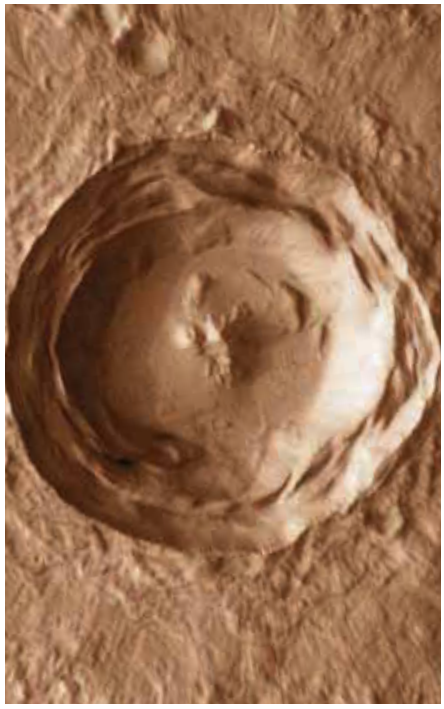
COSMOLOGY

### Cosmic anomalies?

A team of astronomers claims to have found a correlation between the "hot" and "cold" regions of the cosmic microwave background (CMB) and our solar system's orientation and motion.

"All this is mysterious," says team member Glenn Starkman (Case Western Reserve University). The correlation may be a fluke. But, says Starkman, it's more likely that something unknown within our solar system is producing or absorbing the microwaves.

"None of us believes the universe knows about the solar system," he says. — DAN FALK



### MARS PHOTOJOURNAL

**CLASSIC FEATURES.** The Mars Odyssey spacecraft's Themis camera caught a perfect example of a 7.8-mile-wide (12.6 km) impact crater in Isidis. This crater shows a sharp central peak, slumped terraces in the walls, and a grooved ejecta blanket. NASA/JPL/ASU/IMAGE 20041214A

PLANETARY SCIENCE

## How did Mars get so rusty?

How the martian soil became rich in colorful and magnetic iron oxides still eludes scientists. So, a team led by Vincent Chevrier (University of Aix-en-Provence, France) weathered magnetite, iron, and pyrrhotite powder for a year in simulated wet and dry martian atmospheres.

**RUST BUCKET.** Mars' warm color, as at Endurance Crater, comes from iron minerals weathering in a wet carbon-dioxide atmosphere. NASA/JPL/CORNELL

Chevrier's team saw no changes in the magnetite, suggesting that on Mars, the mineral simply weathers out of the bedrock.

Metallic iron remained unchanged, even after a year, in a dry $CO_2$ atmosphere. But in a wet one, it altered rapidly. The sample turned deep, dusky red by day 75 and finally became dark yellow-brown.

The pyrrhotite turned yellow-red after 5 days in the dry atmosphere and took about 100 days to turn a dark, brownish red in the wet.

Both tests produced martian-type minerals: goethite, sulfur, and tiny amounts of iron sulfates, including jarosite, found at Meridiani Planum. — F. R.

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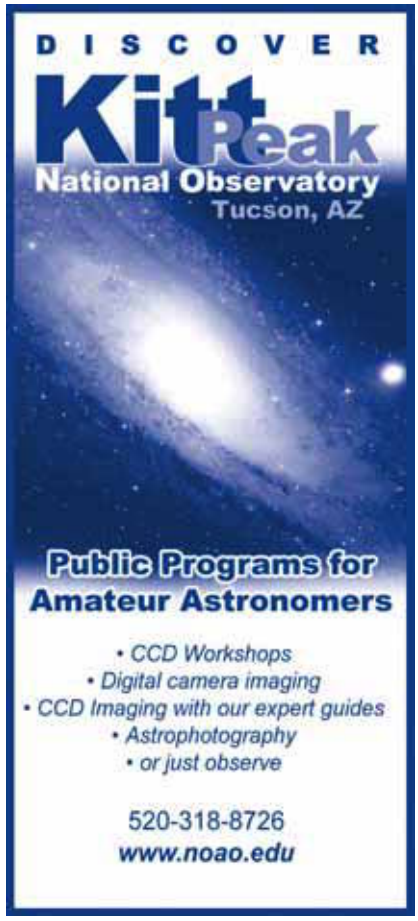

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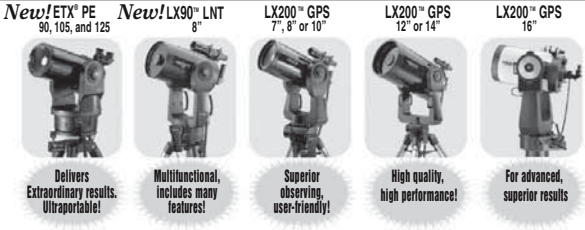

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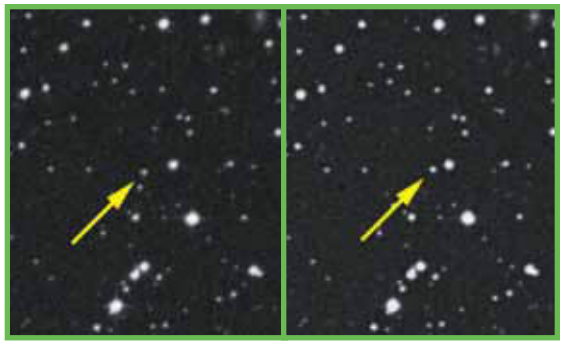
## A grand design: NGC 7424

HYPNOTIC SPIRAL. Yellow with old, red stars, the small central bar in NGC 7424 merges into the pinwheel pattern of the galaxy's arms. The arms are studded with young, blue stars and red nuggets showing where nebulae are making new stars now. ESO



SHIFTY STAR. The nearby star SIPS 1259–4336 changes its position on photos taken in different years. North is upward; east lies to the left. UKSTU/ESO/UNIV. OF EDINBURGH, N. DEACON, N. HAMBLY, J. COOKE

STELLAR ASTRONOMY

## "New" star found near Sol

A faint red star in Centaurus is among the Sun's nearest neighbors, say astronomers in Scotland. They estimate it lies 12 light-years away, less than 3 times farther than Alpha Centauri. Niall Deacon, Nigel Hambly, and John Cooke (University of Edinburgh) noticed a star moving east-southeast at 1.13" per year when they compared infrared sky surveys from different years.

Such a large motion signaled the star might lie nearby. To get a star's distance, astronomers measure its parallax, a positional shift caused as Earth orbits the Sun: the larger the parallax, the closer the star.

Unfortunately, the photographic plates the astronomers used were too crude to reveal any but the largest parallaxes. "I made a mistake in my calculations and thought the star was far more distant than it is," admits Deacon. So, initially, he didn't try to measure the parallax, thinking it would be too small to detect.

But then he looked again at the data. As the team reports in a forthcoming issue of *Astronomy and Astrophysics*, they found a parallax that places the star 11.8 ±1.8 light-years from the Sun.

If its distance is exactly 11.8 light-years, it ranks as the 17th-nearest star system. The star, identified as SIPS 1259–4336, is a red dwarf with a mass only about one-tenth of the Sun's. No one has yet measured the star's Doppler shift, so its speed and orbit in the galaxy are unknown, as is its age.

Deacon estimates the star's brightness at visual wavelengths is 19th magnitude. If the Sun emitted as little light as this star, noon would be darker than a moonlit night. — KEN CROSWELL

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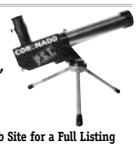

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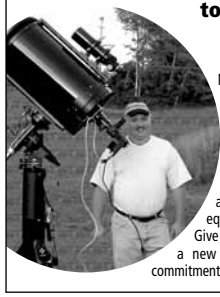

Mike is an avid amateur astronomer & astrophotographer, credited with Six supernova discoveries. Professionally over the past 16 years, Mike has been helping other amateur astronomers choose the best equipment for their needs. Give Mike a call and experience a new dimension in Adorama's commitment to astronomy.

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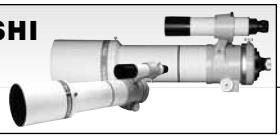

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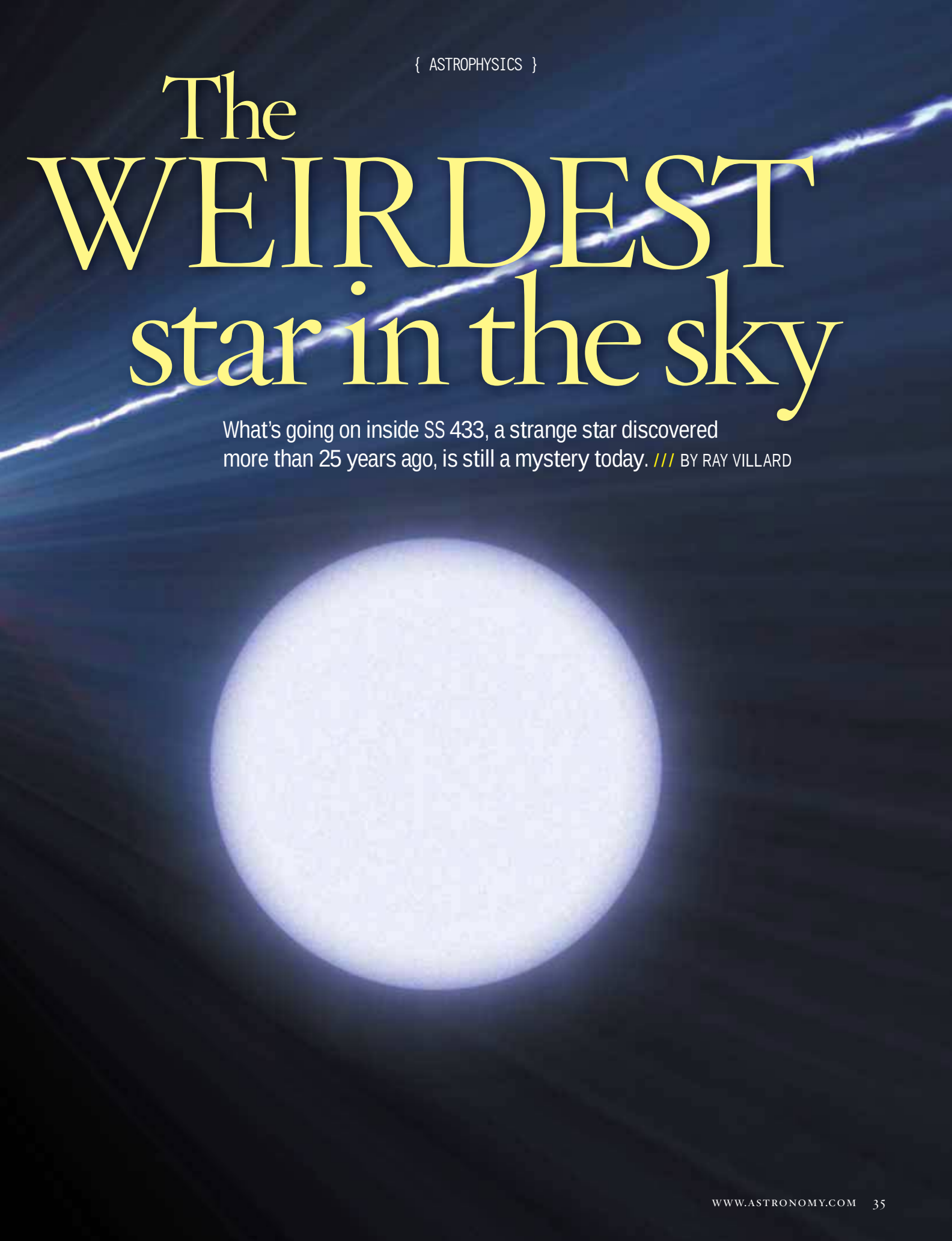
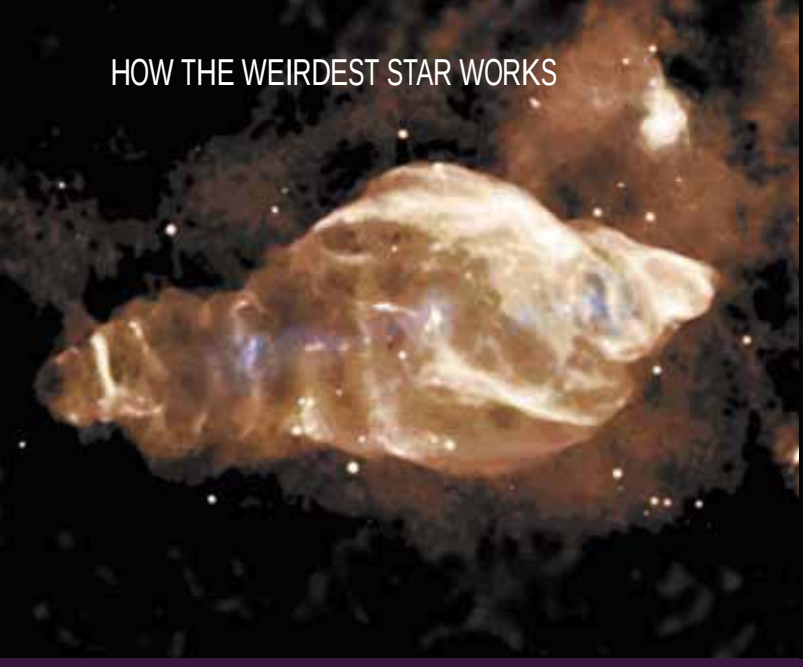
THE SS 433 SYSTEM contains a central, massive object, a companion star, and two high-speed jets. These components lie at the heart of a supernova remnant. ADOLF SCHALLER/OMNICOSM STUDIOS

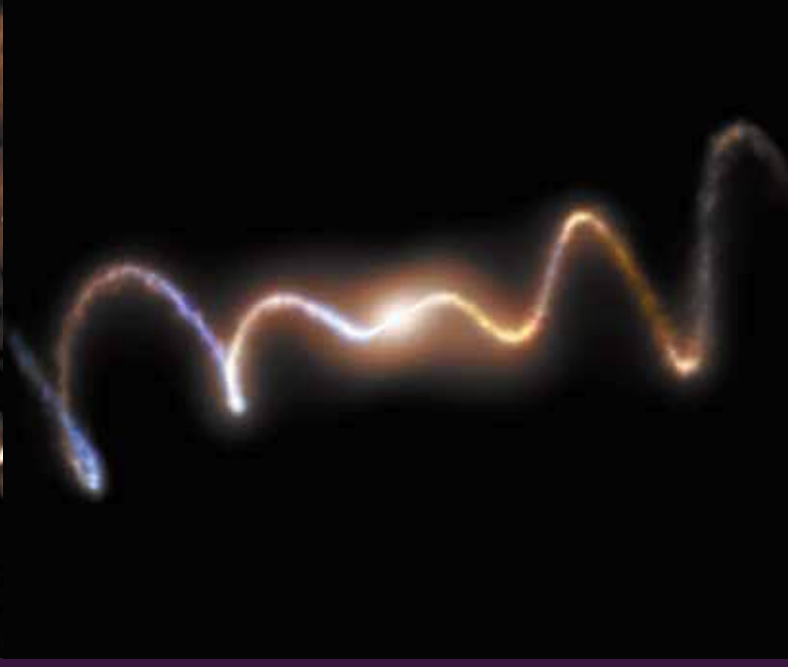
# The WEIRDEST star in the sky

What's going on inside SS 433, a strange star discovered more than 25 years ago, is still a mystery today. /// BY RAY VILLARD





SUPERNOVA REMNANT W50 is a 10,000-year-old shell of gas from an exploded star that surrounds SS 433. At this scale, SS 433 cannot be seen in visible wavelengths. ADOLF SCHALLER/OMNICOSM STUDIOS



SS 433'S CORKSCREW JETS move both toward and away from Earth. In this illustration, the blue components are approaching us and the red parts are receding. ADOLF SCHALLER/OMNICOSM STUDIOS

# In November 1978, Jimmy Carter was president, gasoline was 70 cents per gallon, and NASA's Skylab space station was still orbiting Earth. *Saturday Night Live* was beginning its third season.

The show featured a news parody with Father Guido Sarducci, played by comedian Don Novello. He peered out from under a Padre hat, sporting dark glasses and a robe-shrouded pinstripe suit, to announce a remarkable astronomical discovery:

"Well, there's this-a new planet that they spotted. It's-a gonna be something. It's got these-a astronomers baffled. They call it SS-433, and they found out it's-a coming toward Earth at 30,000 miles a second. But it's also going away from Earth at 30,000 miles a second. It seems-a to be coming and-a going. It just breaks all the laws of physics. They don't know what to make of it."

## Truth stranger than comedy

Some of the more news-attentive TV viewers realized this parody was inspired by real astronomical observations. A few days earlier, the UCLA press office had issued a news release describing the work of astronomer Bruce Margon and colleagues in observing a truly mind-numbing star with the obscure designation SS 433.

The star was described as "coming and going." The object's light was simultaneously compressed and stretched like a spring. This phenomenon, known as the Doppler effect, is commonly measured in stars approaching or receding from Earth. But the velocities for SS 433 had never before been seen in a star.

Parts of the star are hurtling toward us *and* away from us at 16 percent of the speed of light. That's fast enough to travel from here to the Moon in the time it took you to read this sentence.

Ray Villard *is the public information officer at the Space Telescope Science Institute in Baltimore. His most recent article for* Astronomy *was "Lucifer's planets" in the January 2005 issue.*

SS 433 remains the proverbial riddle wrapped in a mystery inside an enigma. A lot has been learned "through accidents — some would say blunders — by a number of astronomers," says Margon. "The bottom line is that SS 433 is almost as extraordinary and obscure as it was 27 years ago."

## A star of many colors

Our galaxy is so big that even something as bizarre as SS 433 took some time to find. Glimmering at 1/1,000 the naked-eye limit, SS 433 is a 14th-magnitude star embedded smack dab in a star-crowded region of the summer Milky Way. The star is the 433rd entry in a catalog of emission-line stars surveyed by Bruce Stephenson and Nicholas Sanduleak in 1977.

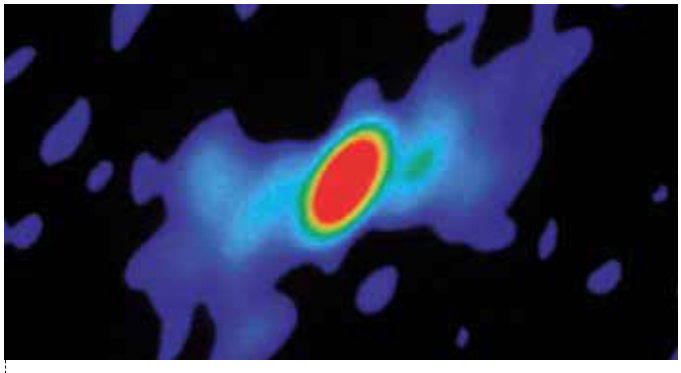
That same year, a radio survey noted a bright source at SS 433's approximate location. However, positional inaccuracies kept astronomers from immediately connecting the two observations as the same strange object. SS 433 was further masked by the fact that it is embedded in a 10,000-year-old supernova remnant called W50, which is also a radio source.

By 1978, astronomers matched X-ray imaging by NASA's High Energy Astrophysics Observatory 2 with radio and optical data. Australian astronomers David Clark and Paul Murdin pointed out how remarkable it was that SS 433 was the source of both X-ray and radio waves. They noted its spectrum showed normal hydrogen, but with some "anomalous" spectral lines.

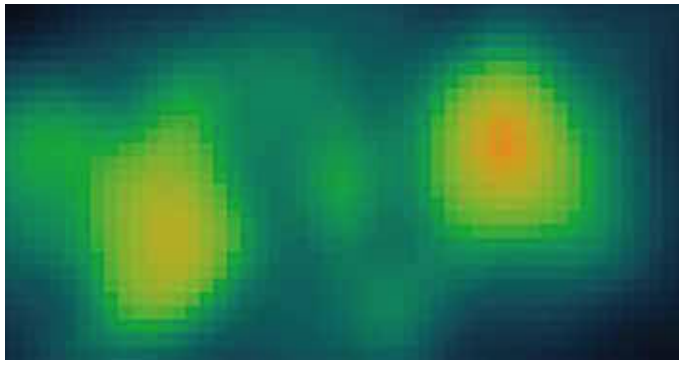
That same year, Margon looked at SS 433 believing it belonged to a class of X-ray objects called X-ray binaries. In these systems, the collapsed stellar core from a supernova orbits a lower mass (hence longer-lived) companion. As the companion ages and

THE COMPONENTS of SS 433 form a strange system. Material from the companion star is pulled into the accretion disk of a massive object, which, in turn, emits energy in two jets. ADOLF SCHALLER/OMNICOSM STUDIOS

AT A MILLION TIMES THE RESOLUTION of the best telescope, we see the accretion-disk core and plasma-jet base of the central object of the SS 433 system — probably a black hole. ADOLF SCHALLER/OMNICOSM STUDIOS



THIS RADIO-WAVELENGTH VIEW of SS 433 shows material being expelled from the star at nearly one-third the speed of light. This VLA image has lots of detail because SS 433 lies only 16,000 light-years away. NRAO/AUI



THIS X-RAY IMAGE of SS 433 is how Chandra "sees" this object. The image shows two high-speed lobes of 50,000,000° F gas 3 trillion miles (5 trillion km) apart on opposite sides of the central object. NASA/CXC/U. AMSTERDAM/S. MIGLIARI ET AL.

bloats to a red giant, its outer gas envelope spills into the deep gravitational field of the compact object. This heats the gas to millions of degrees and liberates a prodigious amount of X rays.

But Margon and his coinvestigators immediately realized the anomalous lines in more-recent spectra were at different places than originally reported by Clark and Murdin. Margon and his team noted a similarity to quasars, which have unusual spectral lines because quasars are so far away, the lines are redshifted by the universe's expansion. SS 433, on the other hand, is clearly inside the galaxy and so represented a new type of object.

Margon's team knew it was observing how the Doppler effect displaces spectral lines: It compresses or stretches light waves by a rapid velocity toward or away from an observer, respectively. Peaks in hot hydrogen emission are blueshifted and redshifted from the stationary hydrogen present in SS 433's spectrum. So, the star, indeed, is "coming and going" simultaneously.

Margon's puzzling results were soon followed by an intensive observing campaign that revealed the redshifted and blueshifted components slow down until their velocities (relative to Earth) reach zero. Then, they "cross over": the redshifted lines become blueshifted and vice-versa. The whole system returns to its original "starting point" every 164 days.

British astrophysicists Martin Rees and Andrew Fabian explained this bizarre behavior: The star is shooting out two beams of energy like a pair of rotating lighthouse beacons. They noted similar phenomena are seen in the cores of galaxies with jets coming from them. The cause — supermassive black holes rapidly accreting gas — was confirmed in the mid-1990s by observations made with the Hubble Space Telescope and other facilities. In this interpretation, the source of SS 433's jets is a black hole or neutron star fueled at a ferocious rate by a companion star. The jets' high speed is essentially the escape velocity from the object.

## Did somebody mention Einstein?

But stranger still is the fact that when the redshifted and blueshifted components switch places, there is a residual redshift corresponding to a velocity of 56 million miles per hour. This seems patently absurd. The escape velocity from the Milky Way is less than one-tenth that speed. If SS 433 were traveling that fast, it would have zoomed out of our galaxy long ago.

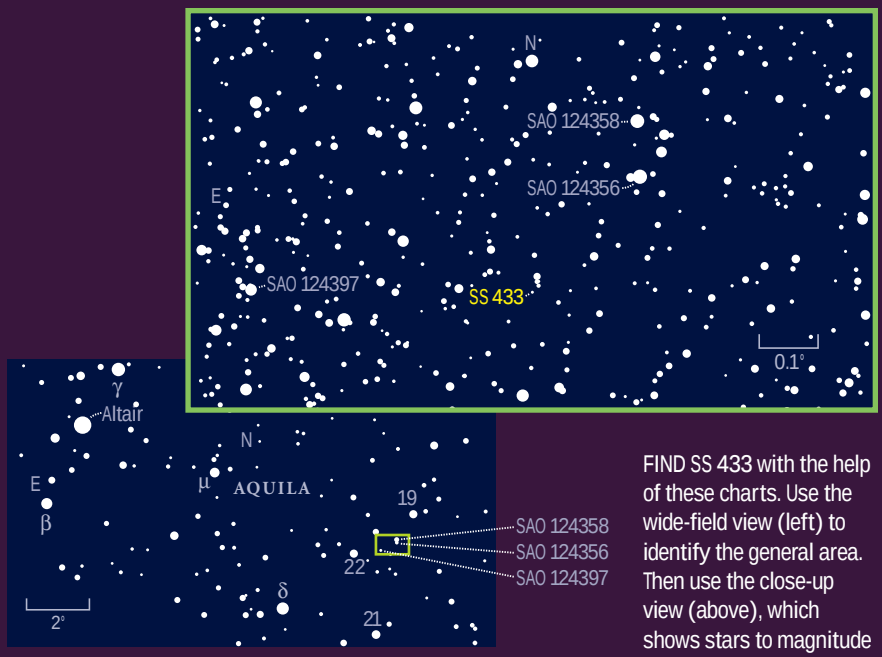
## Observe SS 433

YOU CAN LOCATE SS 433 as a faint speck of light in an 8-inch or larger telescope. SS 433 shines feebly at magnitude 14.1, about the same brightness as Pluto. Find SS 433 in a rich star field within the boundaries of the constellation Aquila, a star figure best seen in summer and autumn.

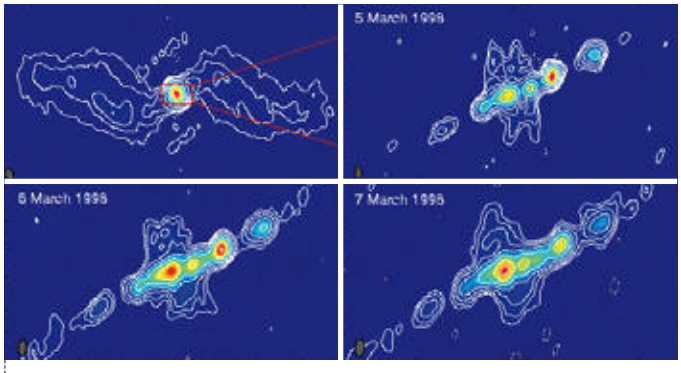
SS 433 lies 4° northwest of the 3rd-magnitude star Delta (δ) Aquilae (which, in turn, lies 8.5° southwest of Aquila's brightest star, 1st-magnitude Altair). Aquila rises in the early evening in July and appears highest in the south a little after midnight. By September, you can find it due south around 9 P.M.

Carefully match what you see in the eyepiece with the map, which shows stars down to magnitude 14.5. Once you do, you should be able to pick out SS 433. Don't expect to see any detail — no telescope will show it as more than a dim point of light. But just glimpsing the light of one of the galaxy's most exotic objects will be worth the effort.

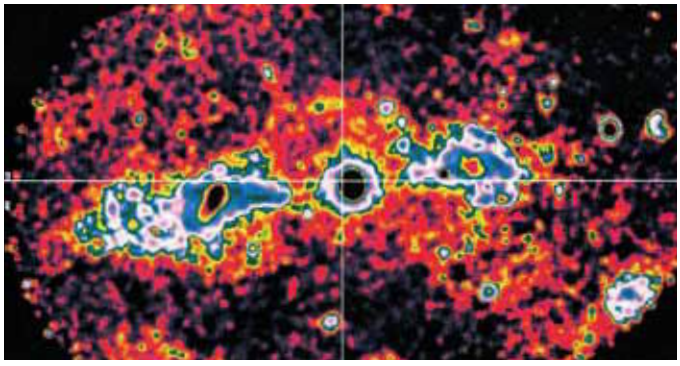
*— Richard Talcott*




FIND SS 433 with the help of these charts. Use the wide-field view (left) to identify the general area. Then use the close-up view (above), which shows stars to magnitude 14.5. *ASTRONOMY:* ROEN KELLY




SS 433 is a special type of X-ray binary star because it exhibits jets of material ejected at speeds close to the speed of light on opposite sides of the system. The image at the upper left was made with the MERLIN and the VLA radio telescopes. The other images are VLBA radio images of SS 433 that show material moving away from the system's center. NRAO



SUPERNOVA REMNANT W50 contains SS 433. This image, taken by the ROSAT X-ray satellite, shows the brightness distribution of the remnant and SS 433. The X-ray emission is generated by interaction between the jets and surrounding material. In this image, the left jet is coming toward Earth.

MAX-PLANCK-INSTITUT FÜR EXTRATERRESTRISCHE PHYSIK

Margon's group realized the gas in the star is time-dilated, as described in Albert Einstein's theory of special relativity. Relativity predicts the faster an object is traveling, the slower its onboard "clock" will appear to tick relative to a stationary outside observer.

Essentially, the jiggling "atomic clock" of excited electrons in the jets' hydrogen atoms is ticking slower, at a lower frequency. "In the end, it was elegantly simple. This is the only [known] astronomical object where relativistic effects are overlaid on Doppler shift," Margon explains.

### Death star

Today, astronomers are probing SS 433 using new telescopes with multiwavelength capabilities. Spectroscopic X-ray observations with NASA's Chandra space observatory probe the inner working of SS 433's "engine," including the jets' seething hot base.

Radio observations with the Very Long Baseline Interferometry (VLBI) program provide an ultra-high-resolution probe to study the outward motion of the relativistic jets. And optical telescopes are being used to characterize the companion star that is essentially the fuel tank for the gravitational engine.

A number of fundamental problems with observing SS 433 in optical light exist. The system has a small angular diameter — only 10 microarcseconds (the apparent width of a dime viewed at a distance nearly halfway to the Moon). Furthermore, the brilliant accretion disk obscures the donor star.

Even the Hubble Space Telescope has not made much progress in unlocking SS 433's secrets. Images taken nearly a decade ago show only a bright dot and, possibly, the barest hint of a jet.

Because the disk wobbles with a period of 164 days, the donor star is above the disk twice a year. Astronomers took advantage of one of these positions to make spectroscopic observations with the 4-meter Mayall Telescope atop Kitt Peak in Arizona. They isolated the companion star from the disk and showed it is a type A supergiant with a surface temperature of 25,000° F. This blistering temperature corresponds to a star of at least 11 solar masses. However, not all astronomers agree with this analysis.

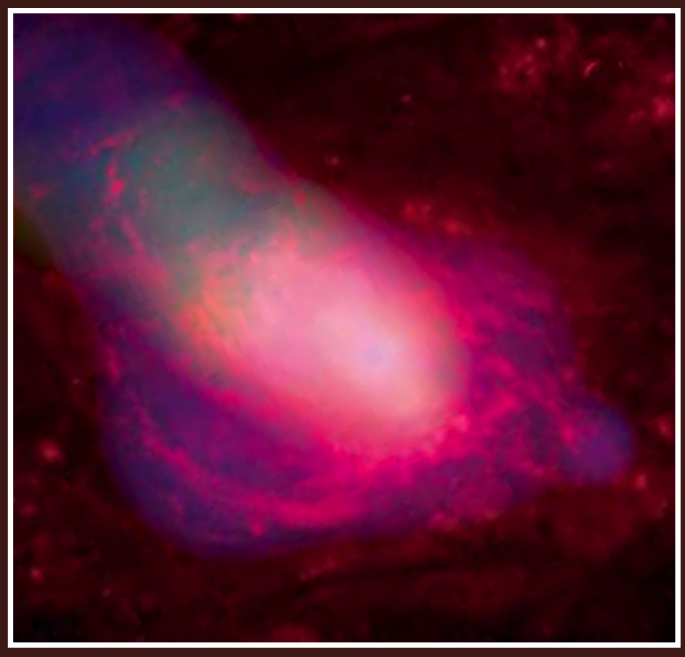
## The AGN connection

SPIRAL GALAXY M77 (NGC 1068) hides a powerful X-ray source from direct view. X rays are scattered into our line of sight, however, by dense material surrounding what is almost certainly a central supermassive black hole.

What's enticing is that SS 433 behaves, at least superficially, like the core of an active galaxy like M77, which pumps torrential amounts of energy into space. The most extreme examples are quasars, the brightest of the active galactic nuclei (AGNs) that inhabited the early universe. The intense gravitational fields from supermassive black holes devouring a flood of hydrogen gas from galaxy collisions must be powering these fireworks.

Although the scale and energy of AGNs are many orders of magnitude more powerful than SS 433, these galaxies are much farther away. "In addition, angular scales are impossibly small to study, and time scales [exceeding 100,000 years] are impossibly long to monitor," says Margon.

Like a model train's tabletop layout, SS 433 is a miniature backyard version of an AGN. "If someone had said we'd find a nearby quasar, that would be wonderful, but be careful what you wish for," says Margon. — *R. T.*



THIS IMAGE OF M77 (right) combines X-ray data from the Chandra Observatory and optical data from the Hubble Space Telescope to produce a false-color, composite picture. P. OGLE (UCSB), A. CAPETTI (INAF), CXO, STScI, AND NASA

For example, Chandra X-ray measurements have been plotted to show how the companion star eclipses the jets. Astronomers use simple geometry to measure the star's diameter, which turns out to be 9 times that of the Sun. Based on this radius, the team using Chandra calculated the star's mass might be as great as 27 times the Sun — 2½ times as massive as the Mayall telescope estimate.

Because SS 433 is so far away, X-ray spectroscopy provides a detailed probe of the conditions in a region below optical telescopes' resolution limits. Chandra can measure gas at the jets' base to within several dozen times the circumference of the black hole's event horizon. It probes the hottest parts of the jets, detects changes, measures where they take place, and observes how they form around the black hole.

Ionized iron is cooked in 100,000,000° F plasma right at the jets' base. Looking farther above the disk, Chandra sees ionized silicon and sulfur where the jets have cooled to 10,000,000° F.

The observable components of the twin jets stretch 600 million miles (970 million kilometers). The "Death Star" beam from this particle accelerator is 5 times the Moon's width at that distance. But that's still razor-thin for an astronomical object.

### Radio tunes in

Detailed views of SS 433's jets have come from the National Radio Astronomy Observatories' Very Long Baseline Array (VLBA) — 10 telescopes strung from Hawaii to the Caribbean Sea to yield an effective aperture of nearly 6,000 miles (10,000 km). At the distance of SS 433, the VLBA can see blobs zipping along the jets' axis like water droplets from a pulsating lawn sprinkler.

VLBA astronomers studied changes in the jets over a 43-day period and observed how the jets flow and flare up at different distances from the black hole. Apparently, not all the pyrotechnics in the system are restricted to the seething accretion disk. At least 50 percent of radio emissions come from the jets' behavior.

The gyrating disk might explain this. It causes the twin beams to carve out cones like twirling Hollywood-premier floodlights. But astronomers don't see these cones until the beams slam into cooler, slower gas in their way.

The twin beams demolish everything in their path. "When a jet hits something, it just blows it away," says Michael Rupen of NRAO. Such destruction creates radio emissions from the jet's vicinity. Even after a cavity is carved out of the gas, it lights up again when the jet comes around later. This means the gas must be replenished by a torrential stellar wind emitted by the star and coming out of the system at 21,600,000 mph.

In fact, the jets are so powerful they're punching into the supernova remnant W50 like a hose hitting a sand pile. The impact distorts W50 from a spherical supernova shell into an egg shape where the jets push the shell in opposite directions along one axis.

### Stay tuned

Nearly a quarter century since his first observations, Margon acknowledges there has been an exciting spurt of progress, but soberly insists SS 433 remains perplexing. In fact, he muses, "We have taken hundreds of spectra. All the points fit. But we don't know the secondary-order effects."

As astronomers probe deeper into SS 433, they're reassured it doesn't break the laws of physics as reported by Father Guido Sarducci. But to this day, SS 433 remains every bit as outrageous as its parody. Nothing else like it has been seen in our galaxy. The big mystery is "Why does it exist at all?" Says Margon, "This can be summarized by two words: Nobody knows."

Astronomers think there may be no more than a half dozen SS 433-type binaries scattered throughout the Milky Way at any one time. That's because stars that go though such a brief spurt of "super-accretion" from their companion stars probably are rare. Somewhere on the far side of our galaxy, another astronomically curious civilization may be looking at their own version of SS 433 and pondering its mysteries. Like us, they are patiently waiting for another one to blaze across the galaxy as a relativistic lighthouse to amaze all who look at it. A

{ GALACTIC ASTRONOMY }

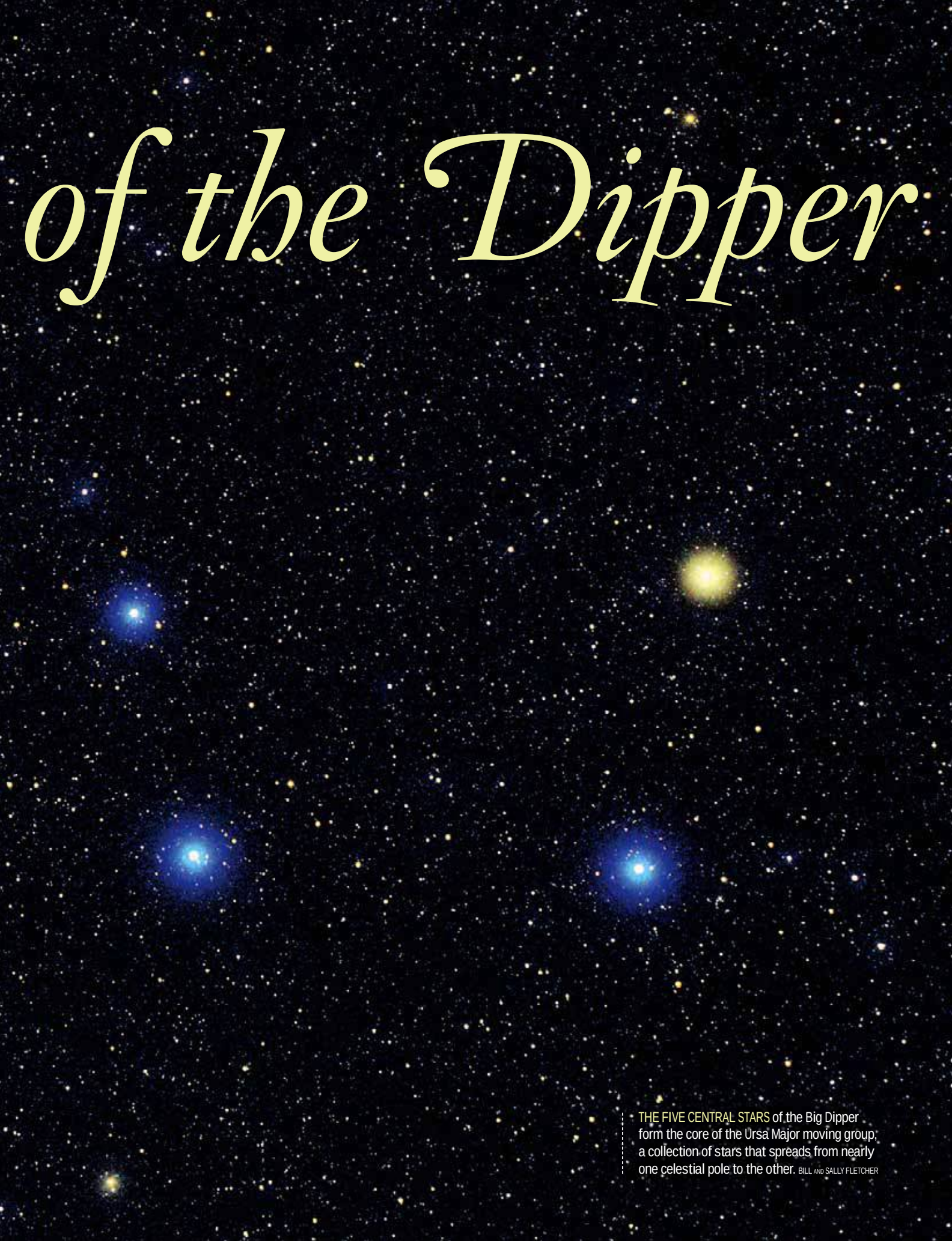
# Descendants

The Big Dipper's extended family covers much of the sky, and is telling astronomers about the behavior of young stars and the chemical evolution of our galaxy. /// BY KEN CROSWELL

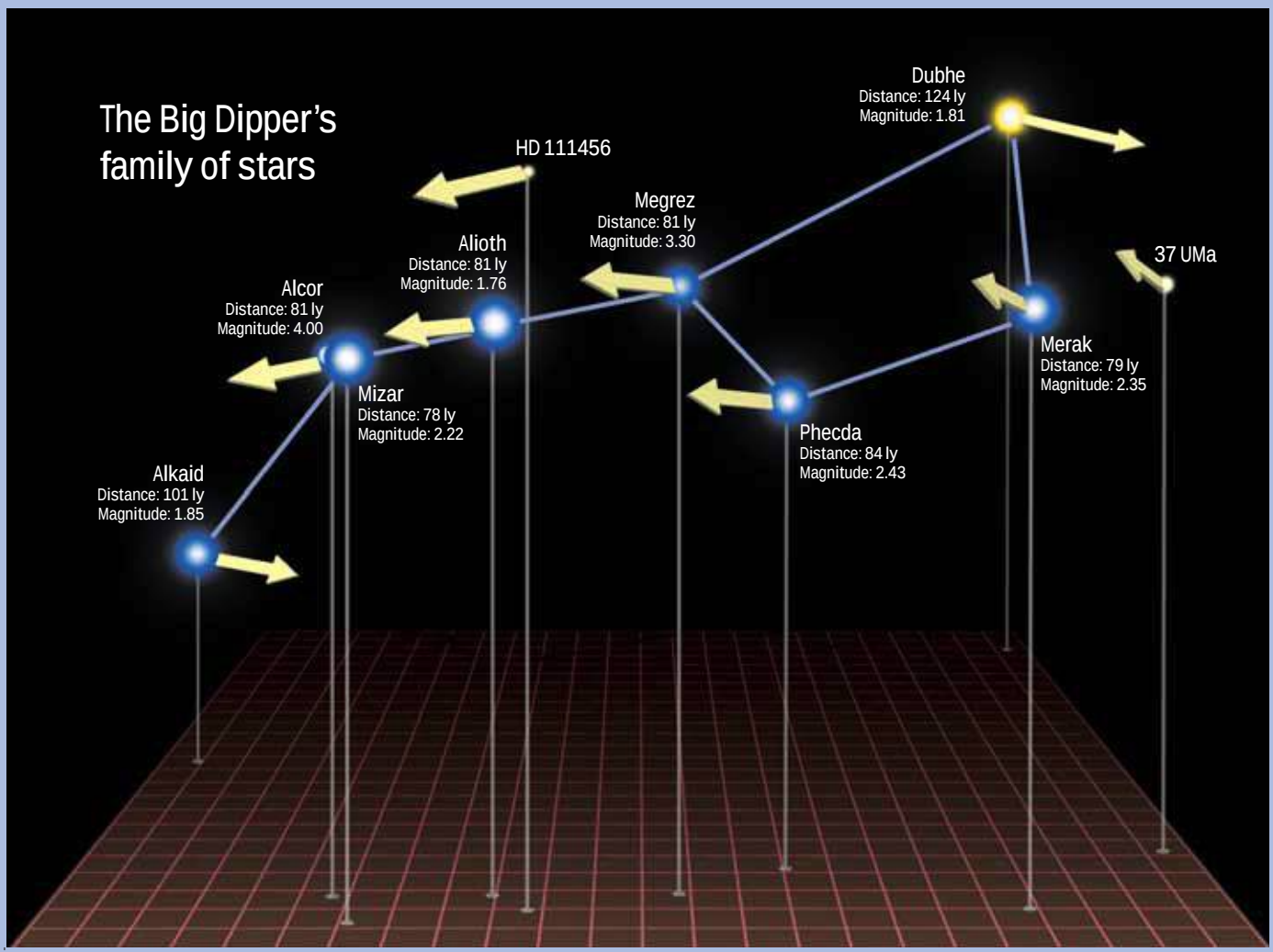
*Seven stars form the Big Dipper,* the first star pattern many skygazers learn. From most northern latitudes, the Big Dipper appears every hour of the night, as faithful as the North Star to which it points. After viewing spectacular constellations such as Orion and Scorpius, seeing the more modest stars of the Big Dipper and the constellation to which they belong, Ursa Major, can feel like coming home.

Astronomy enthusiasts know there's more to the Big Dipper than just its attractive shape. The five central stars — named Merak, Phecda, Megrez, Alioth, and Mizar — are stellar siblings. They were born from the same gas cloud and still travel together through space.

# *of the Dipper*



THE FIVE CENTRAL STARS of the Big Dipper form the core of the Ursa Major moving group, a collection of stars that spreads from nearly one celestial pole to the other. BILL AND SALLY FLETCHER




THE PROPER MOTIONS AND DISTANCES of the Big Dipper's stars reveal that all but Dubhe and Alkaid move through space together. This means the larger group, along with 37 UMa and HD 111456, were born from the same cloud of gas and dust. Distances are given in light-years (ly). *ASTRONOMY:* ROEN KELLY

But the entire Ursa Major moving group spans the sky from north to south. It features dozens of stars — some bright, some dim, some white, some red, some orange, some yellow — scattered across hundreds of light-years of space. Although the Ursa Major moving group is not a genuine star cluster — it's too spread out — it *is* the closest stellar gathering to Earth that shares a common origin. Indeed, it may include Sirius, the night sky's brightest star, which lies a mere 8.6 light-years away.

## Building a relationship

A young British astronomer and author first recognized the Ursa Major moving group. In 1866, before turning 30, Richard Proctor lost all his money in a New Zealand bank failure. "From that day onward for 5 years," Proctor said, "I did not take one day's holiday from the work which I found essential for my family's maintenance."

Proctor's work was studying astronomy and writing about it with great clarity. In 1869, he discovered celestial moving groups: "I find that in parts of the heavens the stars exhibit a well-marked tendency to drift in a definite direction." He noticed the Big Dipper's five central stars share the same proper motion, or apparent movement across the sky from year to year. This "community of motion," as he called it, suggested the five stars are related.

Not even Proctor guessed how widespread the Ursa Major moving group would prove to be. Its nucleus lies 80 light-years from Earth and contains 14 stars, including those which Proctor identified in the Big Dipper. All but one of these stars reside in the Big Dipper's constellation of Ursa Major. (The 14th belongs to the Big Dipper's southern neighbor, Canes Venatici.)

Outside the nucleus, dozens of other stars across the sky move with the Big Dipper's heart. They constitute the moving group's so-called stream. The member star farthest north calls Cepheus the King home. The member star farthest south lies in Triangulum Australe the Southern Triangle. In 1909, Danish astronomer Ejnar Hertzsprung — the "H" in the H-R diagram — even claimed that brilliant Sirius was a likely member.

RICHARD PROCTOR first recognized the existence of moving groups of stars, including the one centered on Ursa Major. DIBNER LIBRARY

### /// CONFIRMED MEMBERS OF THE URSA MAJOR MOVING GROUP

| | Name | HD | Constellation | Distance (light-years) | Spectral type | Apparent magnitude | Absolute magnitude |
|---|---|---|---|---|---|---|---|
| NUCLEUS | 37 Ursae Majoris | 91480 | Ursa Major | 86 | F1 | 5.16 | 3.05 |
| | Merak | 95418 | Ursa Major | 79 | A1 | 2.35 | 0.42 |
| | Phecda | 103287 | Ursa Major | 84 | A0 | 2.43 | 0.38 |
| | Megrez | 106591 | Ursa Major | 81 | A3 | 3.30 | 1.31 |
| | | 109011 | Ursa Major | 77 | K2 | 8.10 | 6.22 |
| | | 109647 | Canes Venatici | 86 | K0 | 8.53 | 6.43 |
| | | 110463 | Ursa Major | 76 | K3 | 8.28 | 6.45 |
| | Alioth | 112185 | Ursa Major | 81 | A0 | 1.76 | –0.21 |
| | 78 Ursae Majoris A | 113139 A | Ursa Major | 81 | F2 | 5.01 | 3.02 |
| | Gliese 503.2 | 115043 | Ursa Major | 84 | G1 | 6.82 | 4.77 |
| | Mizar A | 116656 | Ursa Major | 78 | A1 | 2.22 | 0.32 |
| | Mizar B | 116657 | Ursa Major | 78 | A1 | 3.86 | 1.96 |
| | Alcor | 116842 | Ursa Major | 81 | A5 | 4.00 | 2.02 |
| | 89 Piscium | 7804 | Pisces | 220 | A3 | 5.15 | 1.01 |
| | | 18778 | Cepheus | 202 | A7 | 5.91 | 1.95 |
| | | 28495 | Camelopardalis | 90 | G0 | 7.76 | 5.56 |
| | Chi¹ Orionis | 39587 | Orion | 28 | G0 | 4.40 | 4.71 |
| | | 59747 | Lynx | 64 | G5 | 7.70 | 6.23 |
| | | 71974 A | Lynx | 94 | G5 | 7.51 | 5.22 |
| | | 71974 B | Lynx | 94 | — | 9.09 | 6.80 |
| | Gliese 410 | 95650 | Leo | 38 | M0 | 9.68 | 9.35 |
| | | 129798 A | Draco | 139 | F2 | 6.27 | 3.12 |
| | | 129798 B | Draco | 139 | — | 9.07 | 5.92 |
| | Gemma | 139006 | Corona Borealis | 75 | A0 | 2.22 | 0.42 |
| | Beta Serpentis B | 141003 B | Serpens | 153 | — | 9.95 | 6.59 |
| | Zeta Trianguli Australis | 147584 | Triangulum Australe | 39 | F9 | 4.91 | 4.50 |
| | Gliese 702.1 | 165185 | Sagittarius | 57 | G5 | 5.94 | 4.74 |
| | | 171746 A | Hercules | 112 | G2 | 6.95 | 4.28 |
| | | 171746 B | Hercules | 112 | — | 7.04 | 4.37 |
| | 59 Draconis | 180777 | Draco | 89 | A9 | 5.12 | 2.94 |
| | Gamma Microscopii | 199951 A | Microscopium | 224 | G4 | 4.67 | 0.49 |

This table lists all the stars Jeremy King and his colleagues classify as YES — definite members of the Ursa Major moving group. HD 111456, shown in the illustration opposite, is classified YES?. Spectral types are not available for all stars.

## Torn to shreds

Moving groups are the ruins of star clusters. "We know that stars in our galaxy tend to be born in clumps and groups," says Jeremy King of Clemson University, "but somehow the majority end up in the field. So there must be some sort of segue, some sort of transition, where stars leave their nurseries and end up as isolated beings in the galaxy."

Most stars in the Milky Way are field stars like the Sun — they belong to no cluster at all. Moving groups are the missing link between cluster stars and field stars. A typical star cluster, such as the Pleiades, lives for only a few hundred million years. That's because huge clouds of interstellar gas and dust roam the Milky Way, and their gravity tears stars from the cluster until it disintegrates. Yet, like parachutists jumping from the same airplane, the former members continue to drift through space together.

The Ursa Major moving group constitutes the clearest and closest example. With an age of only 500 million years — a tenth that of the Sun — it is fairly young. Whereas the Sun has orbited the galaxy's center 20 times since its birth, the stars in the Ursa Major moving group have done so only twice. The Sun likely formed with other stars, but today, it belongs to no known group. It is so old that it has lost its siblings. In contrast, the Ursa Major moving group is young enough that astronomers can still locate many of the members.

Ken Croswell *earned his doctorate in astronomy from Harvard University and is the author of* Magnificent Universe *and* Magnificent Mars. *He likes the Big Dipper so much that he put it on the cover of his book* See the Stars: Your First Guide to the Night Sky.

To do so, astronomers must know the velocities of stars through space. Computing a velocity requires three things. First, astronomers must measure the Doppler shift, which reveals the star's velocity toward or away from us — its velocity *along* our line of sight. Second, they must know the star's proper motion, the apparent year-to-year movement *across* our line of sight. Finally, and crucially, they must know the star's distance, because this converts the proper motion into an actual velocity across our line of sight.

Until recently, astronomers knew accurate distances to relatively few stars. The Hipparcos satellite changed all that. In the 1990s, Hipparcos measured precise parallaxes for most bright stars, including those in the Ursa Major moving group. A star's parallax — its apparent shift in the sky as a result of Earth's motion around the Sun — yields its distance through simple geometry.

The Big Dipper illustrates the dramatic improvement in the accuracy of parallax measurement. Prior to Hipparcos, the best parallaxes for the Dipper's five central stars yielded discrepant distances. But the Hipparcos data reveal the central stars all lie about 80 light-years from Earth. Astronomers define moving groups not by common distance but by common velocity. However, without knowing accurate distances, researchers can't know if a star shares the movement of the group.

Like the Sun, the Ursa Major moving group travels through the galaxy, but in a somewhat different direction. Member stars move toward the galactic center about 14 kilometers per second faster than the Sun. They also move about 3 kilometers per second faster in the direction of the galaxy's rotation.

In addition, the stars are sinking through the galactic plane at the modest speed of 1 kilometer per second. Thus, these stars have spent all their lives

THE PLEIADES formed only 100 million years ago. Its youth means it hasn't lost its cluster identity despite a location near the Milky Way's plane. GERALD RHEMANN

THE HYADES condensed from a cloud of interstellar gas and dust some 700 million years ago. Its stars show slightly lower levels of activity than the more youthful stars of the Ursa Major moving group. JEFFREY B. PRINCE

near the Milky Way's plane, the region littered with the densest gas and dust. The original Ursa Major star cluster must have been doomed from the start.

In 2003, King and his colleagues used Hipparcos parallaxes as well as new Doppler shift measurements to compile a list of all possible members of the Ursa Major moving group. They assigned each of the some 220 candidate stars to one of five categories, from definite members to definite non-members: YES, YES?, ?, NO?, and NO. Altogether, 59 stars earned a YES or YES? designation, all likely members of the Ursa Major moving group. Notable among these luminaries are Gemma, the brightest star in Corona Borealis; Menkalinan, the second-brightest star in Auriga; Delta Aquarii; Gamma Leporis; and Beta Serpentis.

Surprisingly, one star that failed to make the YES or YES? grade was Sirius. "That's just the way it came out," says King. "We tried not to look at individual stars and say, 'Oh, this is a favorite, well-known star.' We tried to employ our criteria homogeneously amongst all stars. I hope that's not an offense to anyone." Sirius got classified as ?, which means it might be a member or it might not be.

The members span five spectral types. Because of the group's age, it contains no blue O- or B-type stars. These massive stars have lives measured in millions of years, so all have died. Instead, the most luminous main sequence members are white stars of spectral type A, such as the Big Dipper's central stars. The group also includes lower-mass stars with spectral types of F (yellow-white), G (yellow, like the Sun), K (orange), and even M (red). Most members are main sequence stars like the Sun, calmly burning hydrogen to helium in their cores, but some are more evolved giants or subgiants.

## Youthful activity

Because the Ursa Major moving group is fairly young, astronomers can use it to see how young stars behave. In particular, its G-type stars offer insight into what the Sun was like when it was 500 million years old, a time when life may have been struggling to arise on Earth. Indeed, the Ursa Major group fills a gap. With an age of 500 million years, it's older than the Pleiades (about 100 million years old) and M34 in Perseus (some 200 million years old), but younger than the Hyades and Beehive clusters (both about 700 million years old).

The Sun-like stars in the two young clusters — the Pleiades and M34 — are active. The stars spin fast, generating strong magnetic fields that spawn spots and flares. In contrast, stars in the Hyades and Beehive clusters are quieter. Their spins have slowed and, as a result, their activity is more subdued.

King's team finds the Sun-like stars in the Ursa Major moving group are almost as quiet as those in the Hyades. If the Sun followed the same trend, then it quelled most of its activity over a short interval: It was active when 200 million years old but much quieter at 500 million years. Still, the stars in the Ursa Major moving group are feistier than the present Sun. Indeed, this activity provides another criterion to determine which stars are true members.

## Weird abundances

How can astronomers further refine membership in the far-flung group? David Soderblom of the Space Telescope Science Institute, and a member of King's team, asks: "Could you find abundance patterns that are kind of like fingerprints that tell you this bunch of stars must be related to each other because they have an odd abundance of some element? That would give us a completely independent way of testing the reality of the group."

Intriguingly, ongoing research by a team in Brazil offers just that hope. "It actually started by chance," says Gustavo Porto de Mello of the Federal University of Rio de Janeiro. "[For] my Ph.D. thesis, I had this small sample of solar-type and solar-neighborhood stars. There happened to be one star that was a member of the Ursa Major group — and I found this very weird abundance pattern."

The Ursa Major member is a yellow main sequence star similar to the Sun. It has a spectral type of G5 and lies 42 light-years away in Scorpius. Although it bears the prosaic name HD 147513, it stands out from the nonmember stars because it has a high level of barium and a low level of carbon.

At the time Porto de Mello was doing his initial research, in 1996, he thought only the one star was strange. Then, he and his colleagues observed six other G- and K-type stars in the Ursa Major moving group.

"All of them showed exactly the same pattern," he says. "Such a peculiar chemical pattern is very unexpected and has no parallel in other groups." The stars have lots of barium but little copper. The cloud of gas and dust that formed the Ursa Major moving group must have been chemically peculiar, and the stars inherited these odd abundances when they were born.

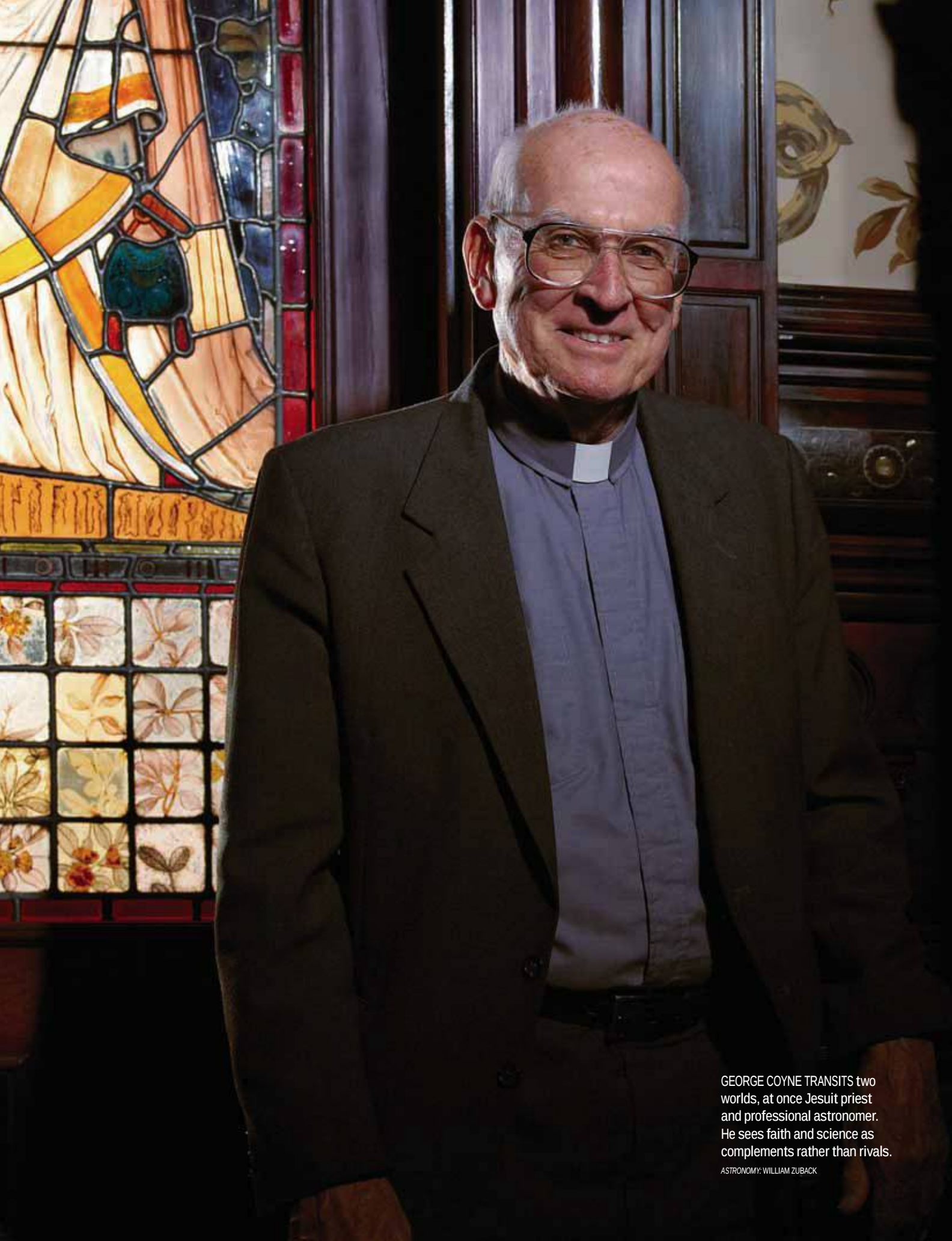
Astronomers can use the odd abundance pattern to locate additional members of the group. "It's another fingerprint," says King. "It's one thing to say the stars have some kinematics in common and they all have the same age, but if you can start showing that they have the same abundance patterns, I think that's really special."

Odd abundances even offer the promise of rescuing the Sun's long-lost brothers from the celestial sea of obscurity. Perhaps the Sun possesses a peculiar enhancement or deficiency of some exotic element. If other stars with the same age share precisely the same abundance pattern, then astronomers may finally catch sight of the stars born alongside the Sun and Earth, some 4.6 billion years ago.

Find out which stars may belong to the Ursa Major moving group at www.astronomy.com/toc

THE ANCIENT CLUSTER NGC 188 in Cepheus has managed to survive billions of years, due in large part to its location well away from the Milky Way's plane. MICHAEL STECKER

A STAR CLUSTER EMERGES from the molecular cloud known as Barnard 86. Ironically, the same molecular clouds that give birth to star clusters can destroy them. ANGLO-AUSTRALIAN OBSERVATORY/DAVID MALIN IMAGES



GEORGE COYNE TRANSITS two worlds, at once Jesuit priest and professional astronomer. He sees faith and science as complements rather than rivals.

*ASTRONOMY:* WILLIAM ZUBACK

# Coyne of the realm

Father George Coyne, the Vatican's chief astronomer, discusses faith, science, and big telescopes with *Astronomy*'s editors. /// BY FRANCIS REDDY

*Father George Coyne has been the driving force behind the Vatican Observatory for the past 27 years. Pope Leo XIII founded the observatory in 1891, but Rome's urban growth and accompanying light pollution eventually forced the facility's relocation from Rome to Castel Gandolfo, the pope's summer residence in the Alban Hills southeast of the city.*

*Relocation was on the table again when Coyne was named director in 1978. Instead, he spearheaded creation of an independent research group at the University of Arizona, Tucson. Under his helm, the observatory undertook construction of the state-of-the-art Vatican Advanced Technology Telescope (VATT) on Mount Graham, near Safford, Arizona. Since completion in 1993, the VATT has been used both as a research instrument and as a technology test bed for the new Large Binocular Telescope, located just a few hundred feet down the road.*

*Coyne was born in Baltimore in 1933 and credits his Jesuit training with igniting his astronomical interests. He earned a doctorate in astronomy at Georgetown University in 1962, and followed it with research at Harvard University and the University of Arizona's Lunar and Planetary Laboratory. Coyne has been dividing his time between the Vatican and the United States ever since he took the observatory's reins.* Astronomy *caught up with him August 18, 2004, when he gave an invited talk at Marquette University in Milwaukee.*

ASTRONOMY: How did you become interested in astronomy? What steered you toward the stars?

COYNE: I remember having a vague scientific interest growing up. … Upon graduation, I entered the Jesuits. As a young seminarian, I had a professor of Greek literature who was probably the best teacher I ever had in terms of his enthusiasm about learning.

So one day, I was called to his office. He said, "I've noticed whenever I'm talking about astronomy or something related, you're sitting on the edge of your chair." I told him I loved it. He began to suggest that I do some reading on the subject, but the seminary's educational system was regimented. I'd go [to the Reading Public Library] every 2 weeks and get two or three books, and he gave me a flashlight because I could read the books only after lights-out. It had all the allure of being a great thing because a lot was happening in the 1950s — and it was forbidden fruit.

A: How has your education and spirituality connected to your interest in science?

C: It's not very direct, to be honest with you. In a sense, they are two compartments of my life. I try to do publishable research in international journals, but then I'm a religious priest.

There is some crossover in my personal life. Knowing more about the universe, and believing that God created the universe, nourished my knowledge of the spiritual background.

I'm giving a talk tonight at Marquette University, a popular talk about how my science influences my view of God. I believe God is creator, and I've never come to that belief through any purely rational process. It's not irrational — I don't think it contradicts reason —- but it transcends reason.

BUBBLE-LIKE NGC 6781, a planetary nebula in Aquila, was blown from the dying sun at its center. All astronomical objects in this article were imaged using the VATT. VATICAN OBSERVATORY

A SMATTERING OF GALAXIES known as Abell 397 lies 360 million light-years away. Spirals like our Milky Way tilt in different orientations, from edge-on (center) to face-on (bottom). VATICAN OBSERVATORY

I mean, why did you marry the woman you married? Because she was so tall and had white teeth and you put that all together? You can never explain to anyone certain decisions from the mental positions that you make. You use the reasoning process, but it's not sufficient. So, at any rate, we've very much promoted this science-religion dialogue, and the pope is still promoting it.

But as religious priests involved in science, our contribution must be good science — recognizable good science, published in international journals.

*A:* Have the perceived conflicts between science and religion lessened during the past few decades?

C: I think it's just a fact of how history has gone along. And, yet, I'm happy that we still do have the contrast, the opposition. We still have Richard Dawkins and that whole school of — sort of "scientism." It's fundamentalism on the part of science, not a religious fundamentalism. Let me put it this way: In my experience, through my whole career as a scientist, there's been a growing tendency among scientists to be more accepting of religious culture.

*A:* Are you saying there are essentially no conflicts between theology and science? Could there ever be? Is there a discovery that would somehow introduce one?

C: I can't imagine a conflict between the two. That's a more faith-based statement than a scientific-based statement, but I believe God created the universe. I can't imagine that God would create a universe in which there would be some contradiction. Ignorance breeds temporary conflicts, there's no doubt about that, but that's ignorance. I would think, undoubtedly, the very distant supernova measurements that have indicated an accelerating universe is by far the most challenging discovery in the past couple of years.

*A:* As a researcher, what attracts you to the areas you study?

C: I think most scientists would agree that these choices are not planned. You choose your doctorate thesis research because you have an interest and there's a good person in the department you think you can work with. I finished my [doctorate] degree in 1962. I did spectral chemical analysis of the lunar surface ... before the Ranger program. That was a fascinating area.

When I finished my thesis, the people at the University of Arizona were just starting up what is now called the Lunar and Planetary Laboratory. Gerard Kuiper from the University of Chicago had come to start up the whole program.

Tom Gehrels was then involved in doing polarimetry of the lunar surface, which complemented what I had been doing. [Polarimetry measures polarization, the direction-dependent properties of light.] From that, I branched off into studying polarization of the extended atmospheres of Be stars. [Such hot, young, B-class stars show emission lines in their spectra, evidence that a cloud of material surrounds each star.]

I then got involved in binary star systems, and through that, into cataclysmic variables, where you typically have this rapid mass exchange between a super dense star — a black hole, a neutron star, or a white dwarf — and a giant star. This became fascinating because polarimetry was a very strong tool for establishing the geometry of

COUNTLESS STARS comprise M56, an ancient globular cluster that orbits in the Milky Way's halo. M56 lies some 32,900 light-years away in the constellation Lyra. VATICAN OBSERVATORY

Francis Reddy *is an associate editor of* Astronomy.

these systems. To the extent that I have some time for research now, I work with cataclysmic variables. Our eight active research scientists each do their own thing.

*A:* What path led you to the directorship of the Vatican Observatory?

C: My bachelor's degree was in mathematics. As Jesuits, we're trained to try and get the superior to tell you what you want to do, but it doesn't always work.

I told them I still had this interest in astronomy and described how it was generated through my education as a Jesuit. They said, no, we don't need astronomers — we need mathematicians to teach at Marquette and Loyola University. So, I began to search for schools where I would study mathematics.

After about a month of serious searching, having interviews and all, I get a letter from the Provincial saying, "We've changed our minds, and we want you to study astronomy." Okay, switch gears. The director of the Georgetown College Observatory, which was the only observatory the Jesuits ran — this is late 1950s, early 1960s — was 65, and it would be 10 years before I was out from graduate studies in astronomy, theology, and ordination. So that was what I was trained to do, to become director of Georgetown College Observatory.

By the time I was done, the observatory no longer existed. Georgetown has a large college and big medical and law schools, as well as other graduate programs that are quite well established. They just couldn't create a competitive modern astronomy department. So there I was, trained for a job that no longer existed. Ultimately, I took a faculty position at the University of Arizona.

In 1978, the director of the Vatican Observatory died suddenly, and I was asked to take over. It was at that time that we decided to look to the future. With the increased population of Rome, the skies were too bright to conduct cutting-edge research, so we founded a research center in Tucson, Arizona — the Vatican Observatory Research Group.

We had no capital investment. All we did was move [ourselves and our books]. … We had use of all the telescopes and all the staff was treated as university faculty. It was a grand opportunity to be involved in the beginnings of the real growth of Arizona astronomy.

THE 1.8-METER VATT, shown here, is formally known as the Alice P. Lennon Telescope. It served as a test bed for technologies used in the Large Binocular Telescope (LBT). VATICAN OBSERVATORY

### /// VATT anatomy

| | |
|---|---|
| Optical system: | aplanatic Gregorian, f/9 |
| Focal length: | 54.05 feet (16.48 meters) |
| Primary mirror: | f/1.0, diameter 6.00 feet (1.83m) |
| Secondary mirror: | f/0.9, diameter 1.25 feet (0.38m) |
| Image quality: | 0.1" throughout 6.8'-diameter, flat field of view |
| Mount: | altitude-azimuth, with derotator |

THIS MOUNT GRAHAM VISTA, viewed from the LBT, includes the Vatican Observatory's Thomas J. Bannan Astrophysics Facility, home of the Lennon Telescope. LORI STILES, UNIVERISTY OF ARIZONA

THE DUMBBELL NEBULA (M27) is a deep-sky favorite. This bright, young planetary nebula lies about 1,200 light-years away in the constellation Vulpecula. VATICAN OBSERVATORY

*A:* Can you tell us about the VATT and how it came to be?

C: There's a string of history here that was unplanned. Nick Walsh, Roger Angel, and others had begun refining their technique for making thin mirrors in a rotating furnace. Their first one was a 2-meter mirror.

They didn't particularly want a 2m telescope — they wanted a 12m telescope. But the mirror made with the new techniques had to be tested. Now, you could either go into a laboratory and do optical tests, or you could build a telescope with it.

So they wondered if our group would be interested in building a telescope using this mirror. The projected cost was about $3.5 million because it's a new technology — you know, it's an f/1 mirror. The University of Arizona offered to pick up one-quarter of the cost.

I went to the Vatican authorities, and they were delighted. "You've been there this short time" — about 5 years — "and you're already invited to participate in this new technology? [We] think you have to do it." But because the cost amounted to a cash outlay of four times our annual budget, they rightly didn't feel they could make the leap. That's when we started a fund-raising foundation in America.

It's a glorious telescope. It has the highest-quality imaging without adaptive optics of any telescope on Earth. We typically get seeing of less than a second of arc, so this telescope can really take advantage of it. We have some images that show seeing at half an arcsecond.

The greatest praise of the telescope is that it's been the test bed for this whole technology of thin, fast mirrors. The Large Binocular Telescope (LBT), which has two 8.3m mirrors and will have the equivalent light-gathering power of 12m, has built upon this telescope. The VATT was the test bed for all that technology — the matching of electronic, mechanical, and optical systems — and it still is. LBT is still doing a lot of testing with our telescope. It's identically the same technology, just a bigger mirror — and there'll be two of them.

The VATT is being used for diverse tasks, from tracking asteroids to looking at nearby galaxies at high resolution in order to observe the stellar population distribution. The overall thing is galaxy evolution. We have a program coordinated with the Hubble Space Telescope to study the aging of galaxies, so the deep-field galaxies of Hubble are being compared to the older, nearby galaxies we see.

Our other major program is to study the distribution and metallicity in our own galaxy — comparing the metallicity of the halo to that of the disk. That has a lot to do with galaxy formation: How rapidly did the galaxy collapse to form a disk? And we're involved in that.

*A:* How much time do your astronomers get to use the telescope?

C: The Vatican Observatory has 75 percent of the time, and 25 percent goes to the University of Arizona. Maybe 10 to 15 percent of the Vatican Observatory time is given to other users who are not directly collaborating with us. We have, however, encouraged people who have a program to collaborate with us, but whether you want to collaborate with us or not, we're happy to give you use of the telescope. After all, we have a staff of eight researchers, and only four of them are really active observational astronomers, so our demands are not full-time.

For instance, Columbia University astronomers had developed a new CCD camera and wanted to test it and use it to search for MACHOs [Massive Compact Halo Objects, such as planets or brown dwarfs, which may make up a significant portion of dark matter]. So they came out and tested it, and one of our astronomers got terribly interested. We now have a

A SWIRL OF SPIRAL ARMS curling from a central bar gives galaxy NGC 7479 the illusion of motion. Blue knots in the arms show where young stars have formed. VATICAN OBSERVATORY

WINTER STARS TRAIL across the clear, dark sky of Mount Graham, setting behind the Vatican Observatory's Bannan Astrophysics Facility. The site's excellent seeing conditions give the VATT the highest-quality imaging without adaptive optics of any telescope on Earth. ROELOF DEJONG

collaborative program where they actually leave the instrument at our telescope, and they come once every 2 months or so for an observing run.

The other thing is, astronomers don't waste a lot of time coming to observe with our telescope. We get 250 photometric nights and 330 days per year where we have more than 6 hours of sunshine. So, that tells you what the night is like.

*A:* Do you provide advice to the pope on any science matters?

C: No, not at all. I've never been asked by him or any of his aides to advise him on any scientific issues. Thank God. The science they need counseling on is biotechnology.

Because our research is very technical, the Vatican simply entrusts this work to us. They expect that we are carrying out our work responsibly. Once in a while, one of the administrators in the Vatican takes a genuine interest in our work, and then we are pleased, but this does not happen very often. After all, people are not selected for administrative careers in the Vatican based on their scientific knowledge.

*A:* During the next 10 years, what do you see happening at the Vatican Observatory?

C: I think we're almost inevitably locked into making contributions to galaxy formation and evolution, which we know so little about. We will have a new director, and we have three or four young Jesuit astronomers, now in studies, who will be joining our staff.

*A:* Is there an historical astronomer to whom you relate?

C: Yes, because of who I am, it's undoubtedly Angelo Secchi [Jesuit astronomer, 1818–1878]. He discovered hydrogen-beta emission lines in Gamma (γ) Cassiopeiae. [Secchi carried out a pioneering study of some 4,000 stars with a visual spectroscope and was the first to classify stars by their spectra.] He had four classifications of stars. He didn't know what the classifications meant; it was empirical.

But that was, if you think about it, when astronomy became astrophysics. For the first time, we had an observational technique that could be used not only to study the position and the motion of stars, but also their physical makeup.

THE MOST FAMOUS STAR WRECK is the Crab Nebula in Taurus. The stellar explosion occurred in A.D. 1054, leaving behind a neutron star in an expanding shell of gas. VATICAN OBSERVATORY

All we have typically is a pinpoint of light. That's all we see when we look at a star even in the largest telescopes. But with correct instruments and my own intelligence, I can tell you how old the star is, how extensive its atmosphere is, and what it's made of. It's unbelievable to think you can do that. A

BY MARTIN RATCLIFFE AND ALISTER LING

# MARCH 05

The beacon rising in the east in midevening is giant Jupiter. Along with Saturn and comets Machholz and C/2003 K4, there's plenty to distract deep-sky observers from their Messier marathons.

## Mercury climbs into view

Shining with ease through the deepening dusk, the innermost planet, Mercury, puts on its best evening apparition of 2005 for Northern Hemisphere skywatchers. Half an hour to an hour after sunset, look low in the west for a bright dot piercing the deep orange to blue twilight sky. No other planet or bright star lurks nearby to create confusion. For the first 2 weeks of March, Mercury climbs away from the Sun, reaching its greatest elongation the 12th. The night before, a day-and-a-half-old crescent Moon sits just to its left, making a lovely pair for binoculars.

During the third week of March, Mercury fades as it takes on more of a crescent shape, a result of it starting to swing between Earth and the Sun. You can follow its quickly changing phase during the clear stretches of weather that tend to occur this time of year.

Saturn's steady yellow light rides high and bright in the south on March evenings. Well away from the thick atmosphere near the horizon, the ringed planet has a good chance of being free of the earthly turbulence that washes away finer details. Take a long look — note the color differences between the inner and outer rings, and look for the black gap, the Cassini Division, that separates the two.

Speaking of Cassini, the robotic explorer of the same name takes its second close look at the icy moon Enceladus March 9. This world, one of the most reflective bodies in the solar system, showed an intriguing array of geological features to the Voyager spacecraft in the early 1980s.

The sparkling winter stars are a sight to behold as darkness falls. Ruddy Aldebaran and Betelgeuse float high, while blue-white Rigel and brilliant Sirius twinkle below. The winter sky appears even more impressive from a dark site, well away from the choking glow of city lights. As you become more dark-adapted, the sky continues to fill with stars to the point where many beginners have a hard time picking out the constellations. Anchor yourself with Orion and its "belt" in the south, and with the Big Dipper standing on its handle in the northeast, and you will find your way to other constellations.

MERCURY STANDS ABOVE the western horizon after sunset this month in its best evening appearance of 2005. LEE C. COOMBS

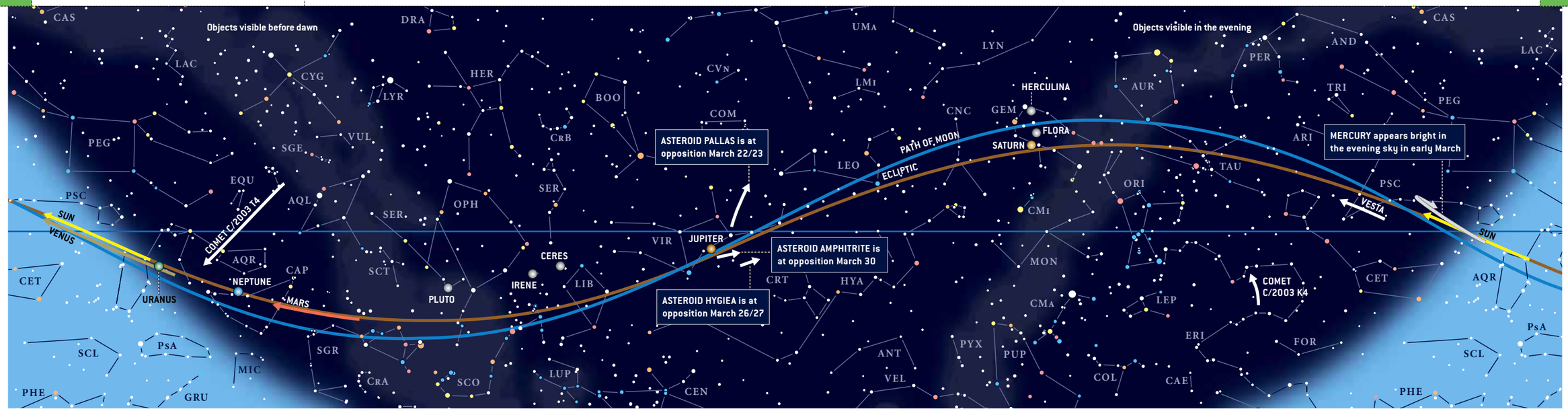
A special sight (but not for city-bound observers) comes into view in the west after the last vestiges of twilight have disappeared. The zodiacal light appears as a pyramid-shape glow, with its base along the western horizon and its rounded tip arching to the left of the Pleiades star cluster. Tiny dust particles that permeate the inner solar system reflect sunlight and cause the zodiacal light.

Comets contribute some of the meteoric dust in the solar system. A modestly bright comet visible this month is C/2004 Q2 (Machholz), now positioned near Polaris. The comet's roundish coma and tail are made from dust and gas ejected from its nucleus. Is your sky dark enough for you to spot it without optical aid?

If you happen to be observing under a dark sky with members of an astronomy club, chances are you'll hear about the Messier marathon. At this time of year, all of the deep-sky objects — dazzling star clusters, distant galaxies, and fuzzy gas clouds — in the Messier catalog can be seen in one long night from dusk to dawn. Such a marathon is more a test of your star-hopping and map-reading talent than your observing skills, but it can be a fun way to spend a spring night.

# Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

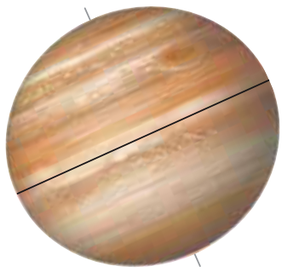



[ 11 ] [ 10 ] [ 09 ] [ 08 ] [ 07 ] [ 06 ] [ 05 ] [ 04 ] [ 03 ] [ 02 ] [ 01 ]

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

[ 31 ] [ 30 ] [ 29 ] [ 28 ] [ 27 ] [ 26 ] [ 25 ] [ 24 ] [ 23 ] [ 22 ] [ 21 ] [ 20 ] [ 19 ] [ 18 ] [ 17 ] [ 16 ] [ 15 ] [ 14 ] [ 13 ] [ 12 ] [ 11 ] [ 10 ]

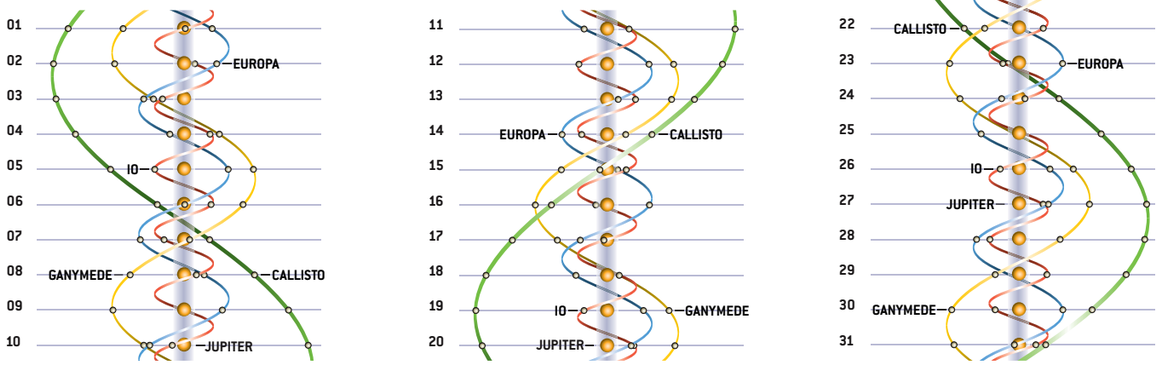
| PLANETS | MERCURY | MERCURY | VENUS | MARS |
|---|---|---|---|---|
| Date | March 1 | March 15 | March 15 | March 15 |
| Magnitude | –1.4 | 0.0 | –3.8 | 1.1 |
| Angular Size | 5.6" | 7.9" | 9.7" | 5.4" |
| Illumination | 88% | 35% | 100% | 91% |
| Distance (AU) from Earth | 1.211 | 0.852 | 1.715 | 1.724 |
| Distance (AU) from Sun | 0.323 | 0.322 | 0.727 | 1.476 |
| Right Ascension (2000.0) | 23h34.2m | 0h41.3m | 23h26.9m | 19h51.7m |
| Declination (2000.0) | –3°18' | 7°10' | –5°08' | –21°47' |

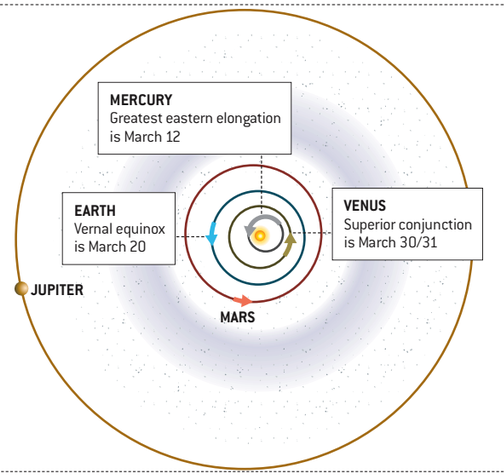


| | JUPITER | SATURN | URANUS | NEPTUNE | PLUTO |
|---|---|---|---|---|---|
| | March 15 | March 15 | March 15 | March 15 | March 15 |
| | –2.4 | 0.0 | 5.9 | 8.0 | 13.9 |
| | 43.6" | 19.4" | 3.4" | 2.2" | 0.1" |
| | 100% | 100% | 100% | 100% | 100% |
| | 4.521 | 8.587 | 21.012 | 30.842 | 30.907 |
| | 5.456 | 9.066 | 20.062 | 30.064 | 30.924 |
| | 13h02.5m | 7h28.2m | 22h38.6m | 21h15.6m | 17h37.0m |
| | –4°58' | 22°00' | –9°22' | –16°01' | –15°09' |

## Jupiter's moons

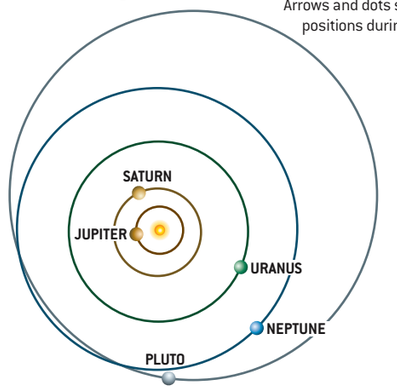
Dots display positions of Galilean satellites at 4 A.M. EST on date shown. South is at top to match the view in a telescope.



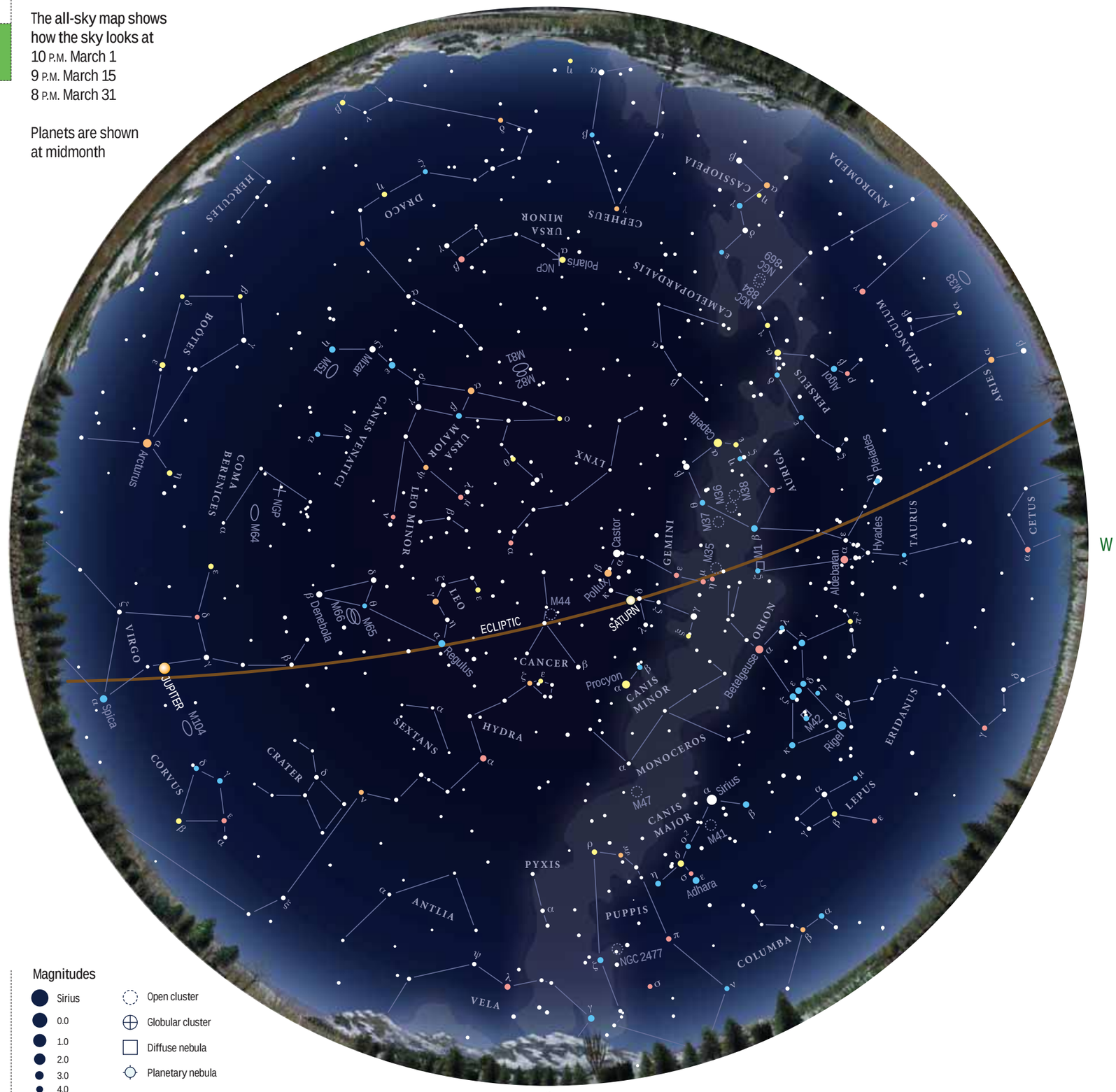

## The planets in their orbits

Arrows and dots show planets' positions during the month.



The all-sky map shows how the sky looks at
10 P.M. March 1
9 P.M. March 15
8 P.M. March 31

Planets are shown at midmonth




Magnitudes

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

# march 05

| SUN. | MON. | TUES. | WED. | THURS. | FRI. | SAT. |
|---|---|---|---|---|---|---|
| | | [ 01 ] | [ 02 ] | [ 03 ] | [ 04 ] | [ 05 ] |
| [ 06 ] | [ 07 ] | [ 08 ] | [ 09 ] | [ 10 ] | [ 11 ] | [ 12 ] |
| [ 13 ] | [ 14 ] | [ 15 ] | [ 16 ] | [ 17 ] | [ 18 ] | [ 19 ] |
| [ 20 ] | [ 21 ] | [ 22 ] | [ 23 ] | [ 24 ] | [ 25 ] | [ 26 ] |
| [ 27 ] | [ 28 ] | [ 29 ] | [ 30 ] | [ 31 ] | | |

03 The Moon passes 0.8° north of Antares, 6 A.M. EST

Last Quarter Moon is at 12:36 P.M. EST

06 The Moon passes 5° south of Mars, 1 A.M. EST

07 The Moon passes 5° south of Neptune, 7 P.M. EST

The Moon is at perigee (225,702 miles from Earth), 10:39 P.M. EST

10 New Moon is at 4:10 A.M. EST

11 The Moon passes 3° south of Mercury, 11 A.M. EST

12 Mercury is at greatest eastern elongation (18°), 1 P.M. EST

17 First Quarter Moon is at 2:19 P.M. EST

19 The Moon passes 5° north of Saturn, 11 A.M. EST

19 The Moon is at apogee (251,560 miles from Earth), 5:53 P.M. EST

20 Vernal equinox is at 7:33 A.M. EST

23 Asteroid Pallas is at opposition, 2 A.M. EST

25 Full Moon is at 3:58 P.M. EST

26 The Moon passes 1.0° south of Jupiter, 11 A.M. EST

Asteroid Hygiea is at opposition, 8 P.M. EST

29 Mercury is in inferior conjunction, 11 A.M. EST

30 Asteroid Amphitrite is at opposition, 5 A.M. EST

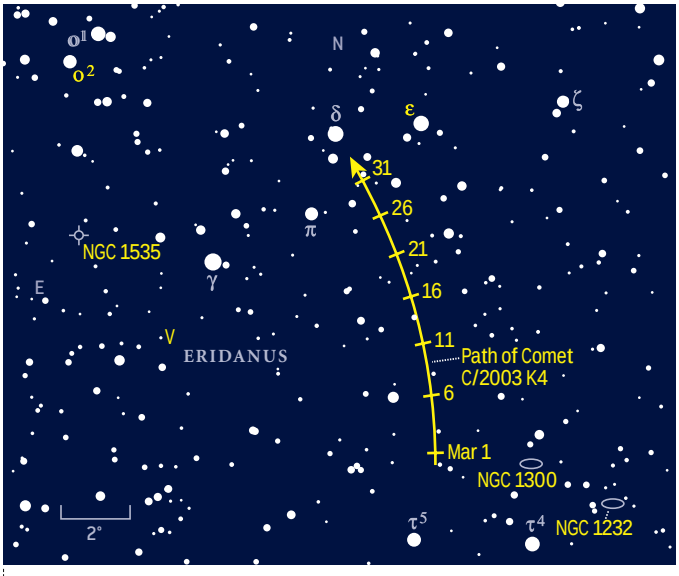
The Moon passes 0.7° north of Antares, noon EST

Venus is in superior conjunction, 10 P.M. EST

For definitions of terms, visit www.astronomy.com/glossary

# THE DEEP SKY

Brilliant blue-white Rigel points the way to the celestial river Eridanus, which meanders around several rewarding sights on the Milky Way's outskirts.




COMET C/2003 K4 slides north this month, passing near several nice doubles and a pretty planetary in Eridanus. *ASTRONOMY:* ROEN KELLY

## A place like home?

The longest constellation pattern in the sky, Eridanus the River stretches from the foot of Orion south to Tucana and Hydrus, well below the horizon for most Northern Hemisphere observers. (Although Hydra covers more territory, the River meanders back and forth so much, its pattern is longer.) One of the River's stars, Epsilon (ε) Eridani, has become fairly famous for being one of the closest Sun-like stars easily visible to the naked eye. The only closer stars brighter than Epsilon Eri are Sirius and Alpha Centauri — and blazing Sirius is far from Sun-like.

Martin Ratcliffe *is former president of the International Planetarium Society.* Alister Ling *is a meteorologist for Environment Canada.*

In 1988, Bruce Campbell of the Dominion Astrophysical Observatory in Victoria, British Columbia, first reported Epsilon has a planet. Recent studies indicate the planet has about 90 percent of Jupiter's mass and orbits its star where our main-belt asteroids lie around the Sun. Unfortunately, there are two strikes against a habitable earthlike planet in this system. First, the Jupiter-like planet has a modestly eccentric orbit, which would likely scatter any smaller worlds. Second, the star seems quite active, throwing out violent flares that likely would prevent a planet in an earthlike orbit from developing a stable climate.

To locate Epsilon, use the circular star map in the center of the magazine, and look for a point forming an equilateral triangle to the southwest of Rigel and Aldebaran. Through the eyepiece, Epsilon appears as a pale yellow-peach dot. Until we get a closer look with more advanced telescopes, our imaginations alone will have to take us to this nearby outpost.

Back toward Rigel lies Omicron$^2$ (o$^2$) Eri. This system harbors the easiest-to-see white dwarf in the sky, one visible through even a small telescope. At low power, a wide pair greets the eye. The fainter of the two, which glows at magnitude 9.5, is the white dwarf. Such a star has passed through its red-giant phase and blown off its outer layers, leaving a hot core of helium and carbon "ash" to cool slowly over the eons.

Interestingly, the white dwarf has a slightly fainter companion that orbits it in about 250 years. Push up the power past 120x, and look about 7" (twice the separation of summer's Double Double) to the northwest. This pair currently shows its widest separation, and a small scope should barely split it.

The nebula NGC 1535 is the remains of a star just heading into its white-dwarf phase. Ultraviolet light from the hot core causes the star's puffed-off shell to fluoresce, creating a shining gas cloud called a planetary nebula. The deep-sky observers who discovered these objects were reminded of ghostly versions of the outer planets, hence their seemingly inappropriate designation.

Under a dark sky, a 3-inch telescope at low power will reveal an out-of-focus "star." Even from the city, an 8-inch scope can pull in enough light from the nebula's 18"-diameter disk to give it a pale blue sheen. Bigger scopes add more detail and an elongated shell surrounding the central star.

For a pleasing color contrast, have a peek at V Eridani, a yellow-orange variable star that lies 4° to the southwest.

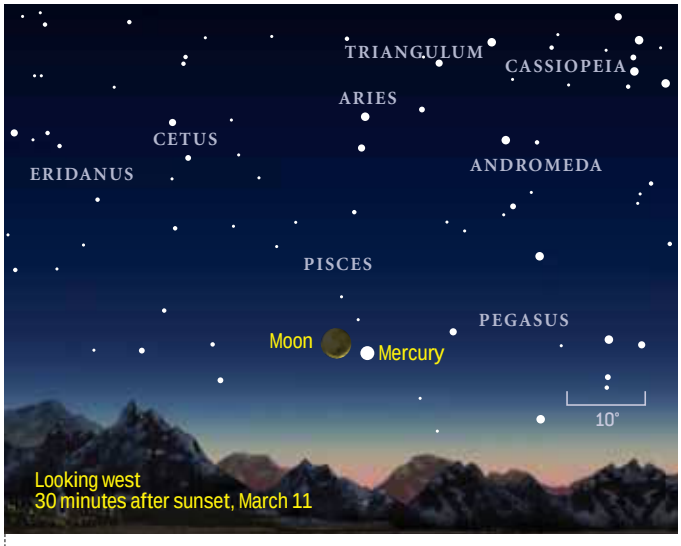
## Crossing the River

Now fading past 9th magnitude, Comet C/2003 K4 (LINEAR) glides slowly across the sky south of Epsilon Eridani. Compare the comet's diffuse shape with that of the nearby face-on spiral galaxies NGC 1300 and NGC 1232. Although the field of view will darken as you increase the magnification, it's the only way your eye can pick out the subtle differences in the structures of these three objects.

PLANETARY NEBULA NGC 1535 shows a subtle bluish tinge through an 8-inch telescope and an elongated shell with larger scopes. ADAM BLOCK/NOAO/AURA/NSF

# THE PLANETS

With Saturn just past its peak and Jupiter approaching its climax, innermost Mercury seeks to garner a little of your observing time.




THE MOON BRUSHES MERCURY the evening of March 11, a great time to spy the elusive inner planet. *ASTRONOMY*: ROEN KELLY

Saturn's dramatic show continues every evening during March. It's that bright "star" you see nearly overhead just as the sky grows dark. Saturn, the solar system's second largest planet, is joined later in the evening by Jupiter, the largest planet, when it climbs above the eastern horizon. This places two spectacular planets in the evening sky throughout March. Elusive Mercury puts in a brief — but rewarding — appearance in the western twilight, while Mars rises during the early morning hours.

Before darkness settles in, Mercury makes its best evening appearance of the year. On March 1, Mercury shines at magnitude –1.4 and stands 6° above the western horizon 30 minutes after sunset. The innermost planet lies in Pisces, but the dim stars of that constellation won't be visible against the bright sky. While Mercury climbs higher each passing day, it also fades a little. By the time it reaches greatest elongation from the Sun March 12, the planet shines at magnitude –0.4. Still, it won't be hard to see because it then lies 11° high half an hour after sunset.

Probably the best evening to view Mercury is March 11, when a 2-day-old crescent Moon lies nearby. You can spy Mercury 4° (eight Moon-widths) to the Moon's lower right. A view of Mercury through a telescope that evening reveals the planet's 7.2"-diameter disk, which appears 48-percent lit.

In the days following its greatest elongation, Mercury remains fairly high but fades rapidly. It reaches magnitude 0.3 March 17, when it lies 10° above the western horizon 30 minutes after sunset and sets 1 hour later.

As the sky darkens and Mercury sets, Saturn waits for attention nearly overhead. While dramatic discoveries continue to pour in from the Cassini spacecraft, beautiful Saturn appears no less dramatic through a backyard telescope. Saturn lies due south around 9 p.m. local time March 1, and about an hour earlier every 2 weeks after. The planet lies in Gemini the Twins, near the pair of bright stars Castor and Pollux.

For observers at mid-northern latitudes, Saturn comes within 15° of the zenith at its highest. High altitude is good — you'll be viewing Saturn through the least amount of Earth's turbulent atmosphere possible. This improves the chances of getting steady images that provide the finest detail on the planet. Although Saturn's location makes it a clear target for evening observation, the high altitude almost demands a star diagonal, which diverts the image 90°, on your scope for comfortable viewing. Otherwise, the nightly contortions of your neck required to view an object almost straight up will remind you, later the next day, that you should have invested in this handy device.

Once you point your telescope at Saturn, the rings scream for attention. They span more than twice the diameter of the planet's disk. The major axis of the rings spreads 44" across, while the minor axis measures 18". Saturn's distance from Earth increases by 42 million miles during March, reaching 822 million miles by month's end.

Observers can get an extra thrill by identifying Saturn's larger moons through a telescope — especially this year, when Cassini will image many of them in unprecedented detail. Titan, the largest moon, shines at magnitude 8.3 and proves an easy target in any

SATURN REMAINS A SHOWPIECE throughout March, when it displays wide-open rings with a conspicuous gap known as the Cassini Division. MARK DANIELS

scope. You can find it due north of Saturn March 3 and 19 and due south March 11 and 27. Saturn's 10th-magnitude moons — Tethys, Dione, and Rhea — show up nicely in a 4- to 6-inch scope.

Enigmatic Iapetus had some of its surface revealed by Cassini late last year. The moon's dramatic dichotomy, with one bright and one dark hemisphere, causes an effect that can be viewed through small scopes from Earth. During March, Iapetus lies east of Saturn but begins to travel westward and brighten slowly. The strange moon varies in brightness by nearly two magnitudes, appearing brighter at its western elongation — a situation that occurs in late April. Iapetus glows at 11th magnitude this month.

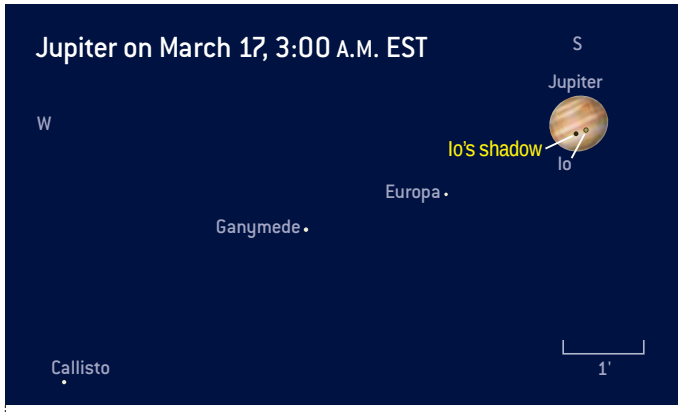
Jupiter gleams at magnitude –2.4 in March, making it the brightest point of light in the sky. It lies between two bright stars in the constellation Virgo — Spica (Alpha [α] Virginis) and Porrima (Gamma [γ] Vir, a nice double star), but neither star rivals Jupiter. The planet's retrograde motion this month carries it closer to Porrima. You can find Jupiter 10 Moon-widths to the lower left of the Full Moon March 25.

Jupiter lies 420 million miles from Earth in mid-March, when it appears 44" across through a telescope. The planet reaches the pinnacle of its current apparition in early April, when it shines brightest, appears largest, and lies opposite the Sun in our sky.

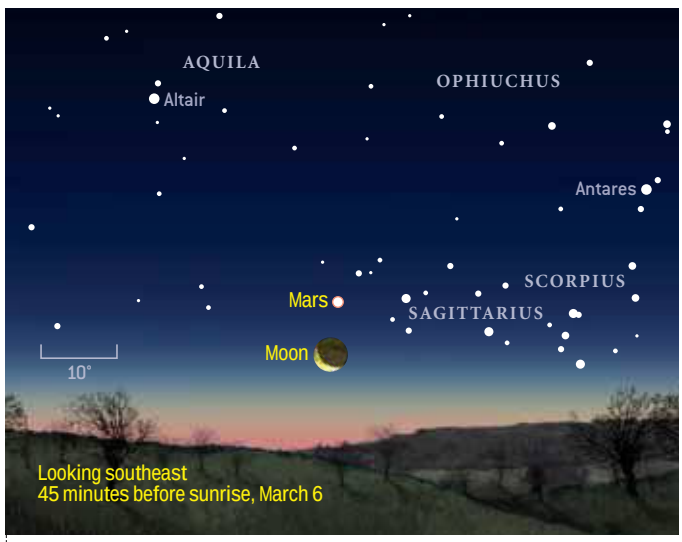
Telescopic views of Jupiter can be wonderful. The most prominent features are two dark belts that straddle the equator. Subtle shadings make up the remainder of the atmospheric features that skid around the planet at breakneck speed. Just remember the planet you are viewing is 11 times Earth's diameter but rotates in less than 10 hours. As a result, in just 10 to 15 minutes, you can detect quite easily the motion of features across the disk. Occasionally, you'll see the salmon-pink Great Red Spot on the Earth-facing hemisphere.

Often, one of Jupiter's four bright moons will cast its shadow on the planet's face. For example, Io's shadow crosses Jupiter's disk on St. Patrick's Day, March 17. Start watching Jupiter at 1:39 a.m. EST, when the shadow begins its transit. Io moves quickly, and the shadow scoots across the disk in 2 hours and 12 minutes. The shadows of the more distant moons move slower. You can see for yourself the night of March 6/7, when Ganymede's shadow traverses Jupiter's disk. The action begins at 1:51 a.m. EST and lasts nearly 3 hours, concluding at 4:32 a.m.

Mars rises around 4 a.m. local time March 1 and lies 10° above the southeastern horizon an hour before sunrise. The relative position of the Sun and Mars changes little during the month. Meanwhile, Earth's orbital motion causes the background constellations to drift behind Mars. In early March, we see Mars against western Sagittarius. By the 20th, Capricornus has slid into our line of sight toward Mars. On the 24th, the Red Planet lies 6° south of Beta (β) Capricorni. Mars remains a tiny object, barely 5" across, when viewed through a telescope. Better views will be seen later this year.




IO'S BLACK SHADOW crosses Jupiter's disk, an event that's easy to see through any telescope, the night of March 16/17. *ASTRONOMY:* ROEN KELLY



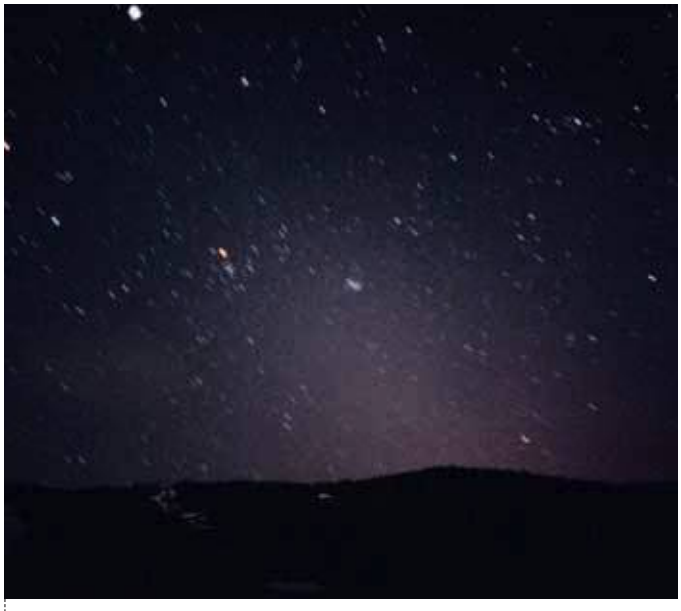

MARS RECEIVES A VISIT from the waning crescent Moon March 6. This provides a pretty sight and a great photo opportunity. *ASTRONOMY:* ROEN KELLY

An attractive conjunction of the Moon and Mars occurs March 6. Set your alarm for around 5 a.m. to catch Mars 6° above a slender crescent Moon. Mars shines at magnitude 1.1, just about the same as Antares, the brightest star in Scorpius. The star now lies some 40° west of Mars. Note the two objects' similar color.

Because the star emits its own light and Mars merely reflects sunlight, their matching color is nothing more than a coincidence. Antares shines a subtle shade of orange because its surface temperature — about 4,400° Fahrenheit — makes it glow rather like a red-hot poker left in a fire. Mars, on the other hand, glows reddish because rusty soil gives reflected sunlight that color.

# METEORS AND MOONS

Although the March night sky offers precious few meteors for backyard enjoyment, you might be able to glimpse more-distant dust particles gleaming by reflected sunlight.



THE ZODIACAL LIGHT glows faintly after twilight ends these March evenings, but you'll need a pitch-black site to glimpse it. JOHN CORDIALE

## The glowing zodiac

Streams of meteors come and go throughout the year, but March tends to be quiet. Sure, there's a small shower, barely detectable, that emanates from Virgo. But there's more than one way to view the dust in our solar system. The easiest is to see the streak of light created as a dust particle plummets to its fiery demise in our atmosphere. Yet before any of these particles strike the air above us, they wander the solar system as meteoroids.

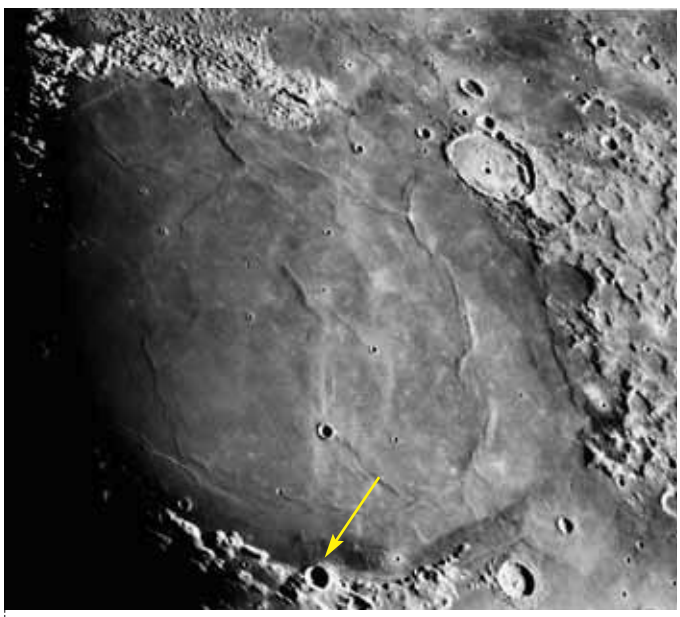
Meteoroids — the name given to solid dust particles — are the debris deposited by innumerable comets and created as asteroids grind against each other. The particles reach their highest density along the ecliptic, the plane of the solar system defined by Earth's orbit. Sunlight shines on these particles and, if conditions are just right, observers on Earth can see the glow. Because the glow follows the ecliptic, which the zodiacal constellations encompass, it is known as the zodiacal light.

March provides the right conditions. This month, the ecliptic makes a steep angle to the western horizon after sunset from northern latitudes. Once the twilight glow has disappeared from the sky, about 90 minutes after sunset, scan above the western horizon for a faint cone of light that extends past the Pleiades. To see the light, you will need clear, dry air and absolute darkness to the west — even an intervening streetlight or glow of a distant town will render it invisible. In the high desert of the southwestern United States, the zodiacal light can be seen almost every clear, moonless night. The subtle glow is sunlight reflecting off billions of fine dust particles — these are the pride of March's meteoroids.

## A sharp-rimmed crater

Near the border between the Moon's Mare Tranquillitatis and Mare Serenitatis lies the 17-mile-wide crater Menelaus. This crater inhabits the rough-edged southern shore of Mare Serenitatis. It appears well-defined, which indicates a relatively young age, and contains a couple of central mountains on its floor. The crater walls rise nearly 2 miles above the surroundings and are finely terraced.

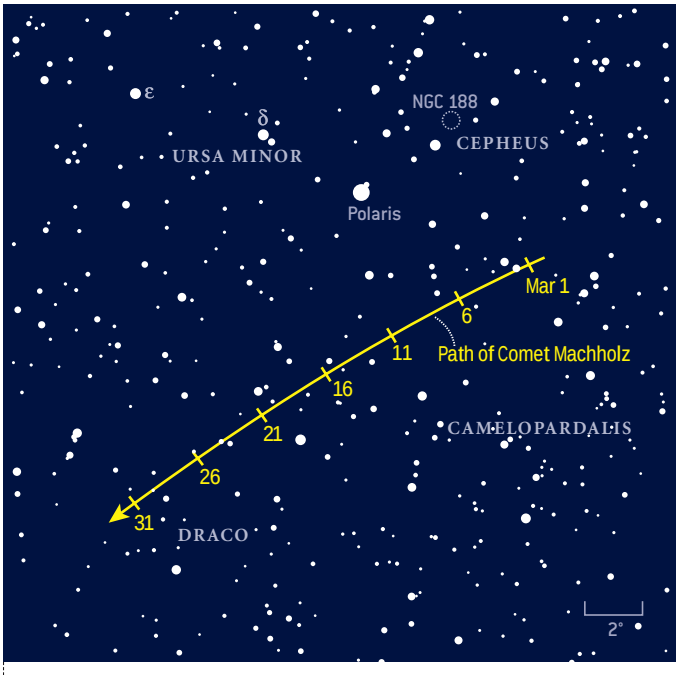
A mountain range extends eastward from Menelaus toward a larger crater, Plinius, which is some 27 miles wide. The range juts out into the flat mare floor at a point called Promontorium Archerusia, just short of Plinius. Intricate rilles crisscross the surrounding plains. You can catch sunrise over Menelaus 2 days before First Quarter Moon, or March 15 this month. Initially, the crater rim will catch the sunlight, but with each passing day, you'll see the crater walls and floor become illuminated. As Full Moon approaches, the crater becomes a brilliant white ring with asymmetric rays.



THE LUNAR CRATER MENELAUS (arrow) shows steep walls and a couple of central peaks when the Sun rises over the feature just before First Quarter phase. FROM *CONSOLIDATED LUNAR ATLAS* (LPL/UA)

# COMETS AND ASTEROIDS

A steady procession of asteroids and comets provides nice viewing opportunities for evening observers this month — and for several months to come.




COMET C/2004 Q2 (MACHHOLZ) traverses the sky's polar regions in March, passing near the North Star, Polaris. *ASTRONOMY:* ROEN KELLY

## Passing the pole

Glowing brightly at 6th magnitude, Comet C/2004 Q2 (Machholz) should show up nicely in binoculars as it swings over Earth's pole on the outbound leg of its journey through the inner solar system. Observers watching from under a dark sky may be able to spy a slightly fuzzy dot with their naked eyes.

Comet Machholz should have a noticeable tail some 1° to 2° long. Comet tails always point away from the Sun, which means Machholz's tail should be angled roughly toward the bowl of the Big Dipper. A comet's tail forms from gas and dust liberated from its nucleus by the Sun's heat. The gas gets ionized by solar ultraviolet light and then carried away from the Sun by the solar wind. The dust is pushed away from the Sun by the gentle pressure of sunlight.

Fork-mounted telescopes like the popular Schmidt-Cassegrain models have a weakness when pointed toward the celestial pole because the eyepiece ends up in an inconvenient location. If you're not planning to do photography or precise go-to observing, consider misaligning your scope 90° to the pole. That way, you can swing the eyepiece into a more comfortable position. Because the comet lies so close to the pole, you'll find the field drifts lazily, which is easy to handle with slow-motion controls.

While you're in the vicinity, check out NGC 188, one of the oldest open star clusters known. It has survived so long because it rarely passes through the high-density regions of the galactic plane. At low power, you'll see dozens of faint stars freckling the background sky.

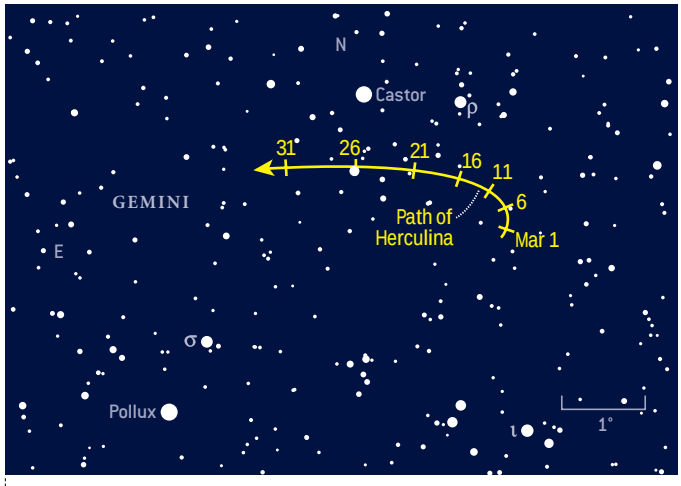
Comet C/2003 K4 (LINEAR) remains with us in the evening sky, but it is fading rapidly as it moves away from both the Sun and Earth. It currently lies in Eridanus, to the west of Orion, and is plotted on page 57.

If you're running an all-night Messier marathon, don't forget to check out Comet C/2003 T4 (LINEAR) in the morning sky. It lies approximately halfway between the bright globular cluster M15 and the Milky Way.

## Rock hunting

Some asteroids are easier to find than others — it all depends on the available signposts. The double star Castor, the northern one of Gemini's two brightest stars, points the way to 532 Herculina. This asteroid glows modestly at 10th magnitude, so you should be able to spot it through a small scope from a city backyard. Herculina measures 130 miles across, similar in size to Saturn's moon Phoebe, which the Cassini spacecraft revealed in detail a few months ago. You can watch Herculina approach a pair of 10th-magnitude stars March 21 and share the field with a gleaming 5th-magnitude star the 26th and 27th.

Just southwest of Pollux lies another asteroid, 8 Flora. And next month, we'll highlight 2 Pallas, a bright main-belt asteroid, as it slides through galaxy country in Virgo.




ASTEROID HERCULINA remains in eastern Gemini this month near the bright double star Castor. *ASTRONOMY:* ROEN KELLY

As nights get warmer, a new set of constellations and deep-sky objects moves into view. /// BY IAN RIDPATH

# Explore the spring sky

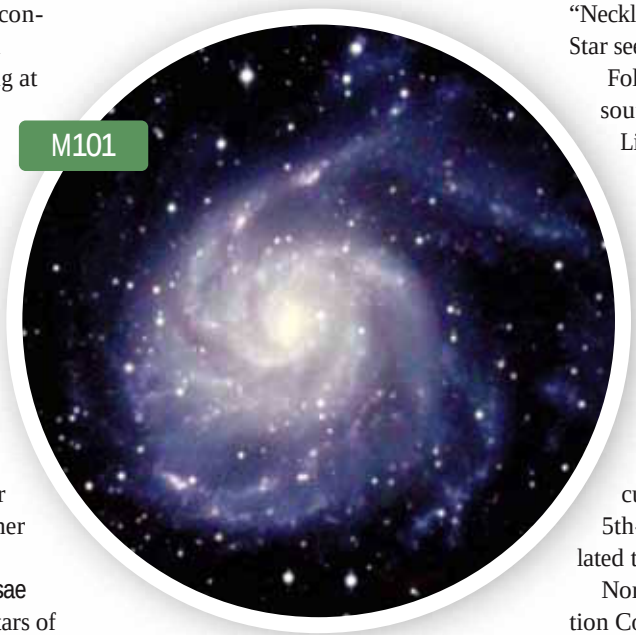
## In the first two parts of this series,

I introduced my favorite deep-sky objects of autumn and winter. Now it's time to look at the finest sights for binoculars and small telescopes during the milder evenings of spring. ☾ At this time of year, the familiar saucepan shape formed by the seven stars of the Big Dipper lies overhead in the evening. The Big Dipper is not a constellation on its own; it's part of Ursa Major the Great Bear. Start by looking at **Mizar** (Zeta [ζ] Ursae Majoris) [tour stop 1], the star in the bend of the dipper's handle. With good eyesight, or binoculars, 4th-magnitude Alcor (80 Ursae Majoris) can be seen nearby.

This pair is the first double star most beginners are introduced to. Actually, Mizar and Alcor form an *optical* double — a pair of stars not physically related. But point a small telescope at Mizar, and a closer 4th-magnitude star becomes visible. Mizar is a true binary; its stars orbit each other every 10,000 years.

Another binary of note is **Xi (ξ) Ursae Majoris** [2], consisting of two yellow stars of magnitudes 4.3 and 4.7. The orbital period of this pair is 60 years. At their current separation, you'll need an aperture of 3 inches (75 millimeters) to divide them. During the next 30 years, the two stars gradually will move apart, providing an opportunity to watch binary motion in action.

In the northern reaches of Ursa Major lies a beautiful spiral galaxy, **M81** [3]. Through binoculars on a dark night, M81 appears as a pastel glow about one-third the apparent diameter of the Moon. One Moon diameter to the north is the irregular galaxy **M82** [4], altogether different in appearance. M82 is smaller and more elongated than M81. For many years, astronomers thought




THIS SPIRAL GALAXY in Ursa Major can be a tough target through small telescopes because its light spreads over a large area. DANIEL B. PHILLIPS

M82 was an exploding galaxy, but they now believe it is an edge-on spiral undergoing a burst of star formation caused by an encounter with M81 several hundred million years ago. Both galaxies are about 10 million light-years from Earth.

About twice as far off is the face-on spiral galaxy **M101** [5], which lies north of the end of the Big Dipper's handle. Binoculars will show its rounded inner regions, but you'll need at least an 8-inch telescope and a dark observing site to trace its spiral arms.

As every scout knows, the two bright stars in the bowl of the Big Dipper farthest from the handle point (away from the bowl's opening) to the North Star, **Polaris** (Alpha [α] Ursae Minoris) [6]. Magnitude 2 Polaris is a double star; its 8th-magnitude companion is visible through small telescopes. A telescope also will reveal a ring of 8th- to 11th-magnitude stars that I call the "Necklace of Polaris," on which the North Star seems to be strung like a lustrous pearl.

Follow the pointers of the Big Dipper southward, and you'll come to Leo the Lion, one of the few constellations that resembles its namesake — in this case, a crouching lion. In the lion's neck lies one of the most regal doubles of the sky, **Gamma (γ) Leonis** [7]. A small telescope with a magnification around 100x divides it into a golden pair of stars with magnitudes 2.2 and 3.5. Each star is an orange giant, and the two orbit each other every 600 years. Binoculars will show another star nearby, 5th-magnitude 40 Leonis, which is unrelated to Gamma.

Northwest of Leo's tail is the constellation Coma Berenices. An interesting object in this region of the sky is a star cluster known as **Melotte 111** [8], which fans out for some 10 Moon diameters south of Gamma Comae Berenices. Like all such large groupings, Melotte 111 is best seen in binoculars. South of this cluster, but not part of it, lies **24 Comae Berenices** [9], an orange-and-blue double of 5th and 7th magnitudes — a beautiful pair in small telescopes.

Coma Berenices also contains the spiral galaxy M64, known as the **Black Eye Galaxy** [10] because of a dark area of dust silhouetted against its nucleus. The galaxy can be picked up in small telescopes, but the dust that causes the "black eye" requires apertures larger than 6 inches to be seen clearly.

TWO BRIGHT GALAXIES, a spiral (left) and an irregular, lie 10,000,000 light-years away in the direction of Ursa Major the Great Bear. RICH JACOBS

Leo faces another zodiacal constellation, Cancer the Crab, at the heart of which lies a famous cluster — the **Beehive Cluster** (M44) [11]. The ancient Greeks could see this object as a misty spot. Unfortunately, under present-day skies, most people will need binoculars to spot it.

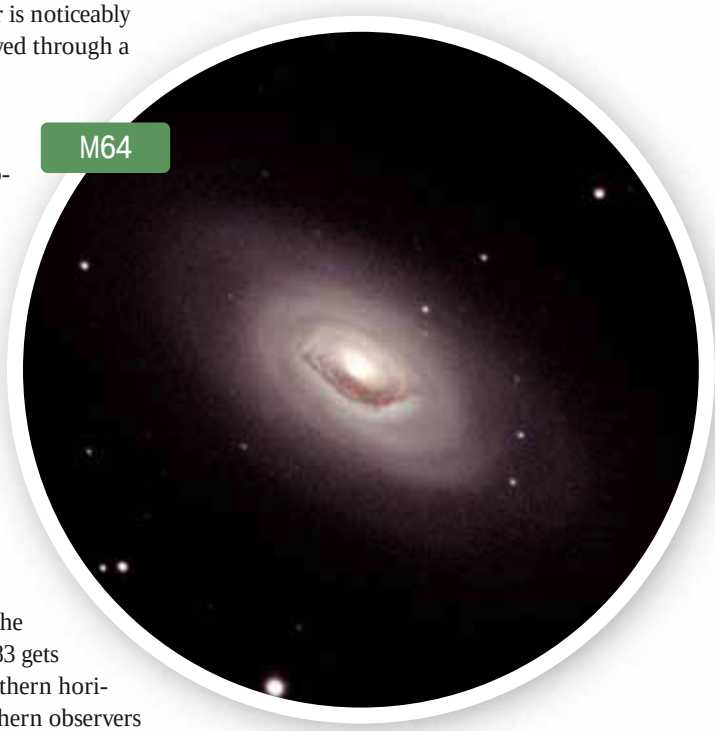
The Beehive's glory overshadows another open cluster in the same constellation: **M67** [12]. Although smaller and denser than M44, M67 still covers a Moon's width of sky. Under a dark sky, you should be able to find it in binoculars, but you'll need a telescope to resolve its stars.

In northern Cancer lies **Iota (ι) Cancri** [13], a 4th-magnitude yellow giant with a nicely contrasting 7th-magnitude blue-white companion. This pair is just detectable in 10x50 binoculars and easy to spot in small telescopes. To the right of the Beehive lies another easily split double star, **Zeta Cancri** [14]. Its components are 5th and 6th magnitudes with an orbital period of roughly 1,000 years.

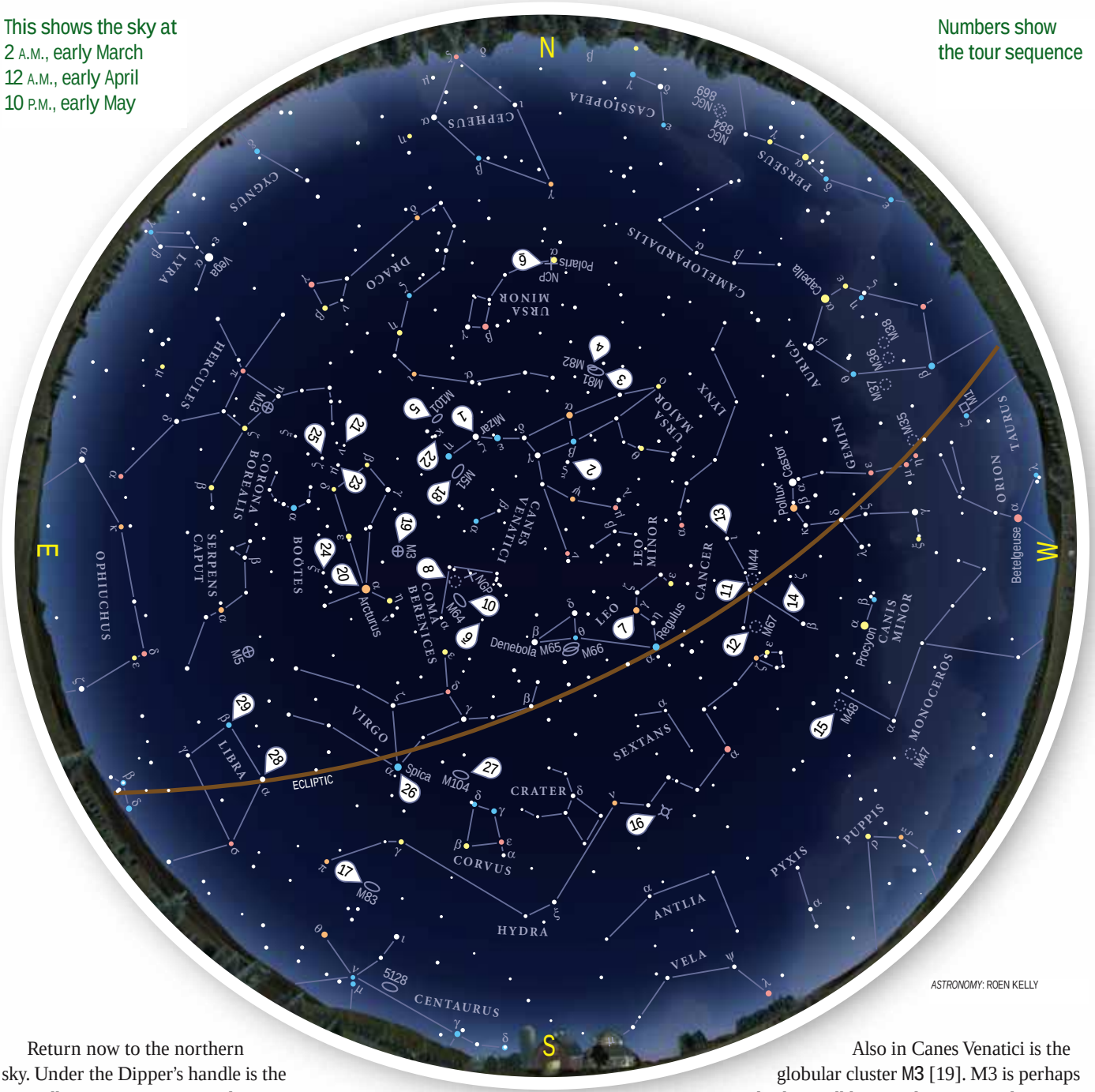
South of Cancer and Leo is the largest constellation, Hydra the Water Snake, which wraps its sinuous length around more than a quarter of the sky. At the head of Hydra, on the border with Monoceros, lies **M48** [15], an open cluster the apparent width of the Full Moon. M48 is detectable easily with binoculars. This star cluster is noticeably wedge-shaped when observed through a low-power eyepiece.

Farther along the water snake's body to the east lies NGC 3242, a planetary nebula known as the **Ghost of Jupiter** [16] because its size and appearance resemble the planet's. Planetary nebulae have a reputation for being difficult to observe, but NGC 3242 is easier to spot than most.

**M83** [17], a beautiful face-on spiral galaxy, lies where Hydra's tail passes south of Spica, which we'll discuss later. Although on the border with Centaurus, M83 gets high enough above the southern horizon to be well seen by northern observers living at middle latitudes. Small telescopes will show it, but you'll need an aperture of at least 6 inches and a dark sky to trace its spiral arms. M83 has been the site of more recorded supernovae than any other Messier galaxy — six at last count.




THE BLACK EYE GALAXY in Coma Berenices sports a dark area of dust silhouetted against its nucleus. BOB AND JANICE FERA




ASTRONOMY: ROEN KELLY

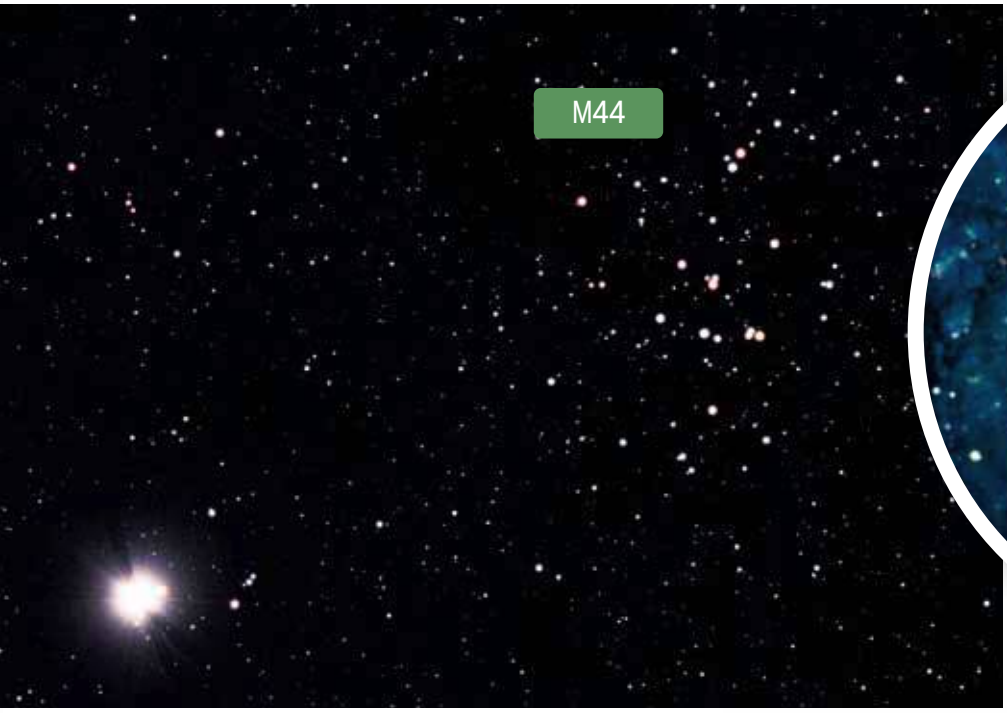
Return now to the northern sky. Under the Dipper's handle is the constellation Canes Venatici the Hunting Dogs. Herein lies an object that features prominently in the development of astronomical thought — the **Whirlpool Galaxy** (M51) [18]. In the days before the true nature of galaxies was known, it was the first galaxy in which spiral structure was observed. Lord Rosse in Ireland made that observation in 1845 with his 72-inch reflector — at that time, the world's largest telescope. Rosse's observation of M51 was an early step in establishing galaxies as systems of stars separate from our Milky Way.

The Whirlpool Galaxy has a smaller companion, NGC 5195, which brushed past it a few hundred million years ago. In light-polluted city skies, telescopes reveal little more of M51 and its companion than their centers, which appear as two bright points enveloped in a mist. Apertures above 8 inches are needed to see the arms. Depending on your site's darkness, you may be able to make out M51 in binoculars as an elongated smudge. No amateur should miss the chance of glimpsing this historic object.

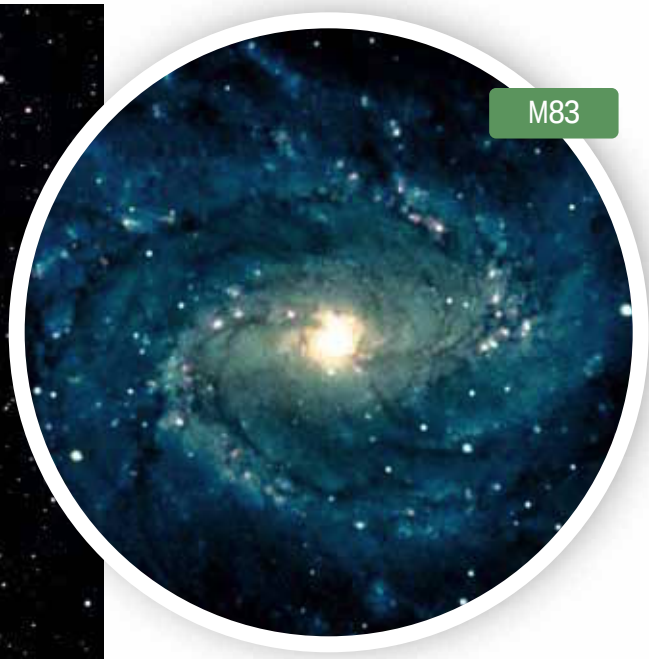
Also in Canes Venatici is the globular cluster **M3** [19]. M3 is perhaps a bit less well known than some other northern globulars but no less impressive. An adjacent 5th-magnitude star helps locate it. M3 is on the limit of naked-eye visibility under a dark sky with good seeing conditions. It's seen easily through binoculars, however, appearing similar in size to the better-known M13 in Hercules. M3 is about 25-percent farther away than M13, however, and is, consequently, more difficult to resolve into individual stars. Use a 4-inch or larger telescope for a good view.

The curving handle of the Big Dipper points to **Arcturus** (Alpha [α] Boötis) [20], the brightest star north of the celestial equator and the emblem of the northern spring

**Ian Ridpath** *is the author of* The Monthly Sky Guide *(Cambridge University Press) and the* Princeton Field Guide to Stars and Planets *(Princeton University Press).*




THE BEEHIVE CLUSTER in Cancer has a brilliant visitor in this image — Jupiter (lower left). This star cluster also is known as the Praesepe. CHRIS COOK




THIS SPIRAL GALAXY in Hydra appears face-on. Through a small scope, you'll see a hazy glow, but a 6-inch or larger telescope will let you trace this galaxy's spiral arms. NOAO

sky. Arcturus draws attention to the surrounding constellation of Boötes, which is noted for its double stars. Start with **Nu (ν) Boötis** [21], an easy binocular pair. The stars, both of magnitude 5, are unrelated but form an optical double. **Kappa (κ) Boötis** [22] is another optical double but the components, of 5th and 7th magnitudes, require a small telescope to divide.

**Mu (μ) Boötis** [23] is a double that will satisfy users of binoculars and telescopes. Binoculars show it as a 4th-magnitude star with a 7th-magnitude companion, but turn a 3-inch telescope on the fainter star and — with suitably high magnification — you'll find an 8th-magnitude companion. The 7th- and 8th-magnitude stars form a true binary with an orbital period of 260 years.

Another genuine binary is **Xi Boötis** [24], a duo of 5th- and 7th-magnitude yellow and orange dwarfs that can be split neatly in small telescopes. Their orbital period is 150 years, so only long-term observations will reveal their relative motion.

While you're scanning this area, look across the border to Corona Borealis the Northern Crown. This constellation is noted for its arc of stars. However, the star of interest, **Zeta Coronae Borealis** [25], is not part of this arc. Rather, Zeta lies in the northern part of the constellation. It consists of an attractive pair of 5th- and 6th-magnitude blue-white stars.

Before bidding farewell to the spring sky, move south again to find Virgo, a constellation shaped like a lazy Y with the bright star **Spica** (Alpha Virginis) [26] at its base. In the bowl of the Y lie numerous galaxies, members of the Virgo cluster, which spill over the northern border of the constellation into Coma Berenices. None of these galaxies is easy to see in small telescopes.

Ironically, the best-known galaxy in Virgo is not a member of the Virgo cluster at all. M104 — the so-called **Sombrero Galaxy** [27] — lies about two-thirds the distance to the Virgo cluster and, consequently, is more prominent than that cluster's members. The Sombrero is a modest-size spiral with a large central bulge seen edge-on. Through small telescopes, this bulge may be all you'll see. Larger apertures reveal a dark lane of dust in the galaxy's plane that gives it the appearance of a Mexican hat.

While in this area, look across the border into Libra. **Alpha Librae** [28], which has the tongue-twisting name Zubenelgenubi, is a wide pairing of 3rd- and 5th-magnitude stars visible in binoculars. The real interest, however, lies with **Beta (β) Librae** [29], called Zubeneschamali, which is one of the few bright stars that — to some observers — shows a greenish tinge. This peculiarity is thought to be due to the chemical composition of Zubeneschamali's outer layers and the star's temperature.

THE SOMBRERO GALAXY is a spiral galaxy in Virgo seen edge-on. Its large central bulge has an easily observed dark lane of dust and gas crossing it. RANDY BREWER

For spring "challenge" objects, see www.astronomy.com/toc

# ASK ASTRO

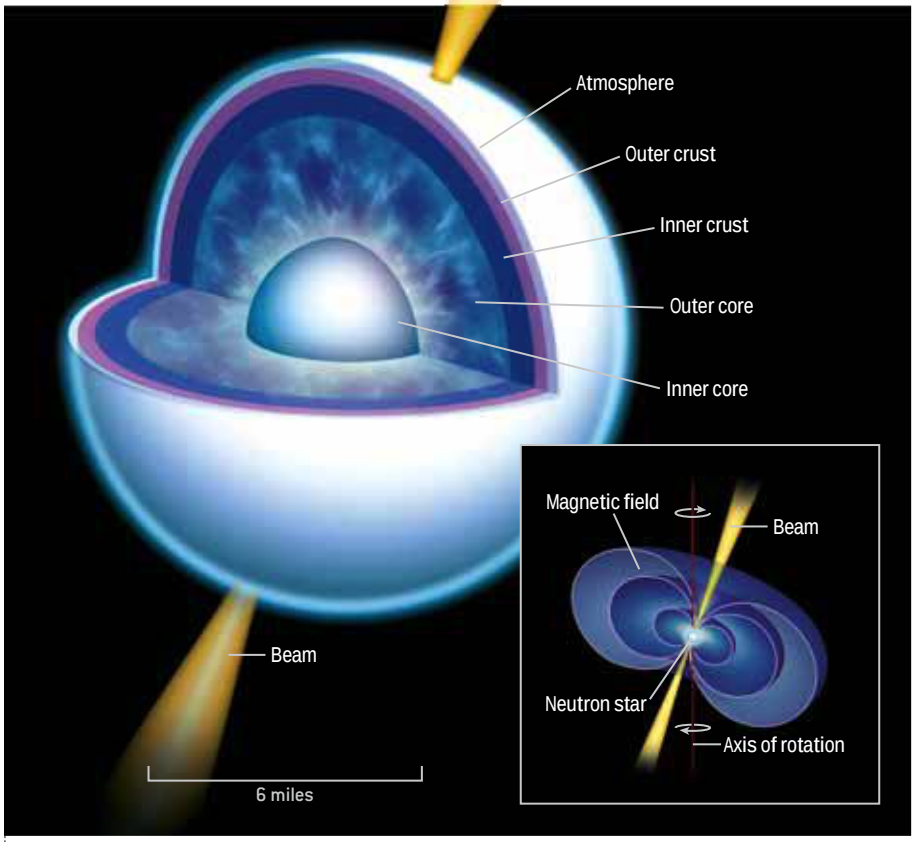
## Visible neutron stars, missiles as launchers

VISIBLE NEUTRON STARS

### If neutron stars don't produce energy from fusion, like normal stars, how can they shine in visible light? — JACOB SIGG, SAN FRANCISCO

Although it is true that neutron stars have, for the most part, consumed all their internal thermonuclear fuel, they tap into other energy sources to produce light. Indeed, neutron stars are remarkably "resourceful" and employ a variety of physical mechanisms to make themselves visible.

A newborn neutron star is incredibly hot — it is, after all, the surviving core of a star that has just collapsed and exploded as a supernova. Gravitational energy released during the star's collapse represents almost 10 percent of its rest-mass energy. For comparison, the fusion of hydrogen to helium releases less than 1 percent of the rest-mass energy of the particles involved. Thanks to this efficient release of gravitational energy, the temperature at the center of a newborn neutron star can reach 500 billion kelvins.




A GLIMPSE INSIDE A NEUTRON STAR would reveal matter at its most extreme. In the crust, bare nuclei are locked in a crystal lattice set within a sea of neutrons. The outer crust may quiver with starquakes; the core may consist of quark soup. *Inset:* Rapid spin and strong magnetism lead to a beam of radiation. Pulsars are neutron stars that happen to be beaming toward us. *ASTRONOMY:* ROEN KELLY

The neutron star loses most of this energy in a matter of minutes, as neutrinos race from the star's core. The remaining energy radiates slowly from the star's surface. Even after a million years, the surface temperature of a neutron star can be several hundred thousand kelvins. An object this hot will shine mostly in the extreme-ultraviolet and soft-X-ray regions of the electromagnetic spectrum, but it will radiate visible light as well.

So neutron stars can be thought of as glowing embers, slowly dissipating the heat generated when they formed. Just how fast they cool depends on the physical properties of their interiors. By measuring neutron-star surface temperatures and ages, astrophysicists hope to learn about the exotic physics occurring within them. One object that has a lot to tell us is RX J1856-3754, an isolated neutron star some 560 light-years away in the southern constellation Corona Australis. As the closest and brightest neutron star known with emissions dominated by heat-flow, RX J1856-3754 allows astronomers a unique opportunity to study, in effect, its bare surface.

Rotation offers another energy source for neutron stars. They spin rapidly at birth because the collapsing pre-supernova star "spins up" — much as a spinning ice skater does when she pulls in her arms. Think of the neutron star as a massive flywheel, storing an enormous amount of rotational energy. It's likely neutron stars also are born magnetized. With both a strong magnetic field and fast rotation, a neutron star produces strong electromagnetic currents that can accelerate charged particles to high speeds, producing radiation over a broad range of wavelengths, including light.

The pulsar at the heart of the Crab Nebula, which spins on its axis about 30 times each second, is the most famous

example of a fast-spinning, magnetized neutron star. But the Crab pulsar is steadily slowing down by about 13 nanoseconds every year. This miniscule change in its rotational period amounts to a loss of far more energy than we observe as visible light from the pulsar, although astronomers debate just how rotational energy is converted into light.

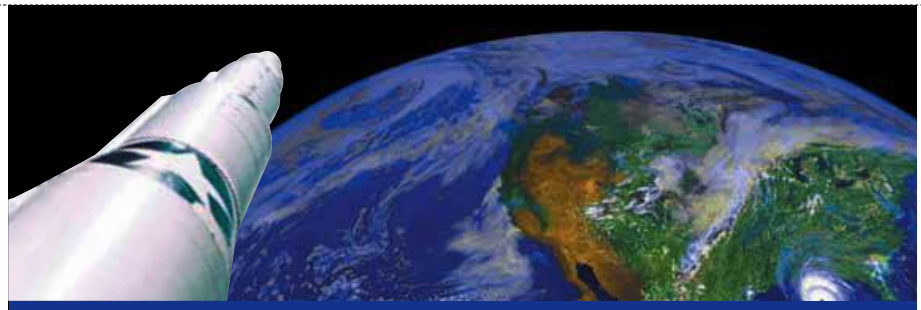
Some neutron stars do produce energy by thermonuclear fusion on their surfaces. This happens in close binary systems where matter flows from a normal star to a neutron star, a setup responsible for some of the brightest X-ray sources in the sky. The donor star supplies material rich in hydrogen and helium, which becomes heated and compressed as it piles up in a layer on the neutron star's surface.

Eventually, the density and temperature of this layer become high enough to trigger a thermonuclear runaway. In seconds, light elements fuse into a complex mix of heavy elements and, in the process, release a prodigious amount of energy — the equivalent of more than one hundred 15-megaton thermonuclear bombs exploding over every square centimeter of the neutron star's surface. The explosion heats the star's surface to several billion kelvins. Astronomers call such events X-ray bursts.

About 80 X-ray-bursting neutron stars are known in our galaxy; each can erupt several times a day. A burst radiates most of its energy as X rays and a small fraction as light. But the X rays shine on both the accretion disk and the companion star, heating them strongly and increasing the total light we see coming from the binary. By studying simultaneously the X-ray and optical signals, astronomers can deduce the size and distribution of matter within the binary system. — TOD STROHMAYER, GODDARD SPACE FLIGHT CENTER, GREENBELT, MARYLAND

## MISSILES AS LAUNCHERS

**Can we turn Minuteman missiles into cheap launchers to deliver small payloads to the Moon and Earth-passing asteroids?** — DOUG KAUPA, SPOKANE, WASHINGTON



### Small U.S. launch vehicles compared

| Name | Minotaur | Pegasus | Taurus | Minotaur 4 | Athena | Delta 2 |
|---|---|---|---|---|---|---|
| First launch | 2000 | 1990 | 1994 | — | 1995 | 1990 |
| Stages | 4 | 3 | 4 | 4 | 3 or 4 | 3 |
| Payload | 750 lbs. (340 kg) | 975 lbs. (440 kg) | 2,360 lbs. (1,070 kg) | 3,800 lbs. (1,735 kg) | 4,520 lbs. (2,050 kg) | 11,300 lbs. (5,125 kg) |
| Payload to GTO | N/A | N/A | N/A | N/A | N/A | 4,120 lbs. (1,870 kg) |

SMALL U.S. LAUNCHERS include Minotaur and the yet-to-be-launched Minotaur 4, both of which use government-supplied motors from decommissioned ballistic missiles. Minotaur uses motors from the Minuteman 2 missile, shown above. D. E. MANUSZEWSKI, JR./USAF

Both the U.S. and Russian space programs have long histories of using missile hardware for space exploration — the Redstone, Atlas, and Titan boosters used to put astronauts in orbit during the Mercury and Gemini programs were all modified missiles. Rockets in the Atlas and Titan family still are used today for unmanned launches, but they aren't cheap.

However, components from Minuteman missiles now are used to deliver payloads to low Earth orbit (LEO). The 4-stage Minotaur rocket, developed by Orbital Sciences Corporation, uses Minuteman II motors in its first two stages and can loft a 750-pound (340 kilogram) payload into LEO. A more advanced version, called Minotaur 4, will contain elements from decommissioned Peacekeeper missiles and will be able to deliver about five times more mass to LEO.

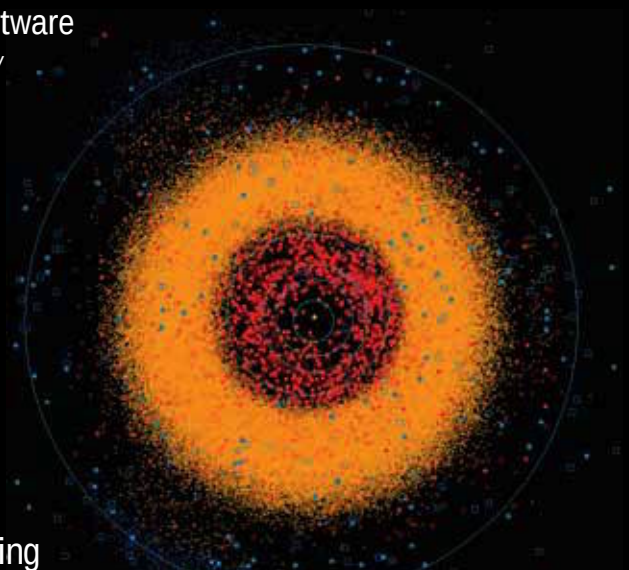
Getting to the Moon or beyond is, however, currently beyond the ability of launchers based on ballistic missiles. Such a booster would need to deliver its payload so the orbit's apogee — that is, the farthest point from Earth — reached Geostationary Transfer Orbit (GTO), the starting point for a slow outward spiral to the Moon and elsewhere. The European Space Agency's 770-pound (350 kg) SMART-1 satellite recently used this approach. Launched as a secondary payload on an Ariane 5 rocket, SMART-1 reached GTO and fired an innovative electric propulsion unit that provided a small but nearly continuous thrust for 13 months. This expanded the spacecraft's orbit until the Moon's gravity could capture it.

A Minotaur launch costs about $20 million, which at the moment is about as inexpensive as it gets for putting a payload into orbit. Bear in mind, the launch vehicle is only part of the cost. You still have to pay for contractors — this alone can reach 65 percent of the total cost — as well as fuel, range and ground support, and permits. Low-cost vehicles certainly help, but these other factors play a significant role in setting the minimum cost for placing payloads into orbit.

Bottom line: We can and do use converted missiles to put payloads into LEO. Ultimately, though, we're limited by the fact that such boosters were designed to loft warheads into suborbital ballistic trajectories, which require much less energy than placing an equivalent weight into Earth orbit. — BILL COOKE, MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALABAMA

If you own a telescope and CCD camera, add a little software and get started doing asteroid science. /// BY DAVID HEALY

# Join the search for space rocks



ASTEROIDS of the inner solar system are shown here as seen from above. The outer circle represents Jupiter's orbit, the orange dots represent main belt asteroids, and the red dots represent asteroids presently within Mars' orbit. MINOR PLANET CENTER

## "Jeff! JEFF! It came back without a parenthesis!" I exclaimed to Jeff Medkeff, my asteroid-hunting partner. This outburst was prompted by an e-mail report from the Harvard-Smithsonian Center for Astrophysics' Minor Planet Center (MPC) on one of our sets of asteroid observations. "Without a parenthesis" in front of the MPC's preliminary designation for the asteroid means — for the moment at least — an object's position cannot be matched with any known asteroid orbit. In essence, you've discovered a new object.

Observations returned from the MPC (the worldwide clearinghouse for asteroid and comet observations) preceded by a parenthesis signify the asteroid's position has been linked with the orbit of a previously known object. You'll become familiar with these idiosyncrasies — and more — if your goal is to hunt asteroids.

Notifying an astronomer about his or her discovery by means of missing punctuation somehow seems appropriate for the Minor Planet Center. This august body's imperturbable style was perhaps best exemplified when early calculations of the orbit of an asteroid (the notorious 1997 $XF_{11}$) suggested it might hit Earth and wipe out civilization. For that announcement, the MPC permitted itself an unprecedented emotional outburst. The doomsday orbit (published in an *International Astronomical Union Circular*) was followed by a single exclamation point!

### A flood of new discoveries

The spectacular impact of Comet Shoemaker-Levy 9 on Jupiter in 1994 apparently got the attention of the United States Congress. NASA is now devoting a tiny slice of its budget to fund searches for asteroids that might someday hit Earth. In the last few years, professional surveys have discovered tens of thousands of previously unknown asteroids. Also, amateur astronomers, using smaller telescopes, have discovered thousands. At last count, the MPC's rapidly growing database included more than 250,000 asteroid orbits. Of these, about 90,000 have been tracked sufficiently, according to the MPC, for their provisional designations to be replaced with permanent numbers.

The majority of known asteroid orbits are for Main Belt Objects (MBOs). Typically, these asteroids are mountain-size rocks orbiting between Mars and Jupiter. The professional surveys, however, are searching for more dangerous quarry — near-Earth objects (NEOs). These so-called Earth-crossers have orbits that intersect or might someday intersect Earth's orbit. Fortunately, no NEO yet discovered poses a significant threat.

ONE OF THE TWIN 1-METER telescopes of the LINEAR asteroid search program at the U.S. Army's White Sands Missile Range near Socorro, New Mexico, gets ready for a night's observing session. To the despair of amateur asteroid hunters, LINEAR has discovered nearly 200,000 asteroids, including virtually all of the bright ones. MIT LINCOLN LABORATORY, LEXINGTON, MASSACHUSETTS

### Automating the search

The traditional method of hunting asteroids was the technique Clyde Tombaugh used to discover Pluto. The telescope operator took two photographs of the same area of sky several hours (or several days) apart. He compared the plates visually using a blinking machine, measured the positions of any objects that "hopped," or

THE ASTEROID BELT lies mainly between the orbits of Mars and Jupiter. Amateur astronomers, using small telescopes and CCD cameras, have discovered thousands of these objects. MARK A. GARLICK

ASTEROID 243 IDA shows details in this false-color image taken by the Galileo spacecraft about 14 minutes before its closest approach from a distance of roughly 6,500 miles (10,500 km). NASA

moved, during the interval between the two photographs, and sent the measurements to the Central Bureau for Astronomical Telegrams. The process was so laborious, time-consuming, and expensive that few astronomers — amateur or professional — attempted it.

Today, the professional surveys (of which New Mexico's LINEAR; Arizona's LONEOS, Catalina, and Spacewatch; California's Palomar Mountain; and Hawaii's NEAT are currently most active) search the skies in automated fashion. Computer-controlled telescopes equipped with CCD cameras take, over the course of a night, three to five images each of dozens or even hundreds of regions of the sky.

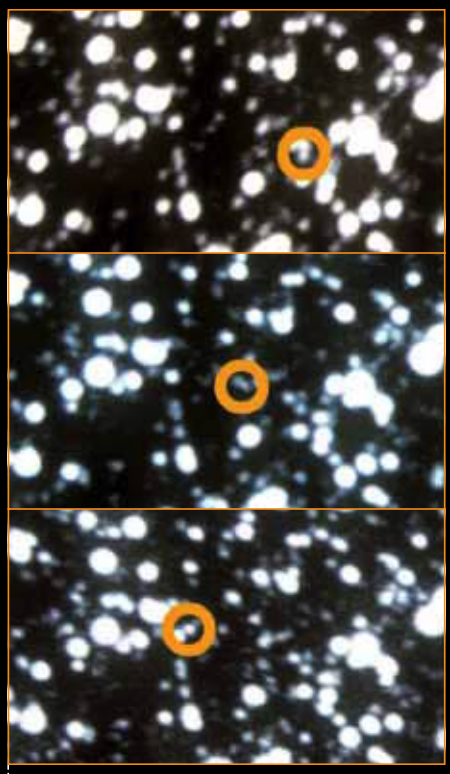
David Healy *is a contributing editor of* Astronomy. *He fled New York 10 years ago to establish a private observatory under the dark skies of southeastern Arizona.*

Each set of images is then superimposed digitally. Any object that steadily shifts its position among the stars in the interval between the exposures is an asteroid, a satellite, or a comet.

The surveys have automated the detection process because the enormous number of images makes "eyeball" searching impractical. LINEAR alone has submitted more than 10 million observations to the MPC and received 198,000 new asteroid designations.

Observers submit precise asteroid positions (not the images themselves) via e-mail to the MPC in a standard format. The surveys also automate the measurements of asteroid positions and compare them with the positions of stars in the field of view.

The MPC sorts the observations and either links a submitted position to the orbit of a previously discovered asteroid or assigns it a new, provisional designation. Thus, thousands of new asteroids are being imaged, detected, measured, and given a designation without ever having been seen on a computer monitor or observed through a telescope.



THE THREE DISCOVERY IMAGES of asteroid 2003 $MZ_1$ show its movement against background stars. The circles marking the asteroid were generated by Bob Denny's *Visual PinPoint* software. DAVID HEALY

## Enter the amateur

Many observers not into computerized astronomy enjoy locating and identifying asteroids with small telescopes. Indeed, the brightest asteroid, Vesta, is occasionally visible to the naked eye.

To observe asteroids visually, you need to know the time the target asteroid is in a region of the sky favorably situated for your site. You also need a good star chart of the region.

The chart should show stars as faint as your target asteroid. Make two observations an hour or so apart to confirm a sighting. If you sketch the star field, when you compare your drawings, one of the "stars" will have moved against the background of more distant points.

A good place to start choosing asteroids to observe is the "Comets and asteroids" page in "The sky this month" section of *Astronomy*. A more comprehensive guide to currently observable asteroids is Brian Warner's annual MPO Asteroid Viewing Guide, which can be ordered at *www.minorplanetobserver.com*.

Lowell Observatory has a rich lode of services for the amateur asteroid observer at *asteroid.lowell.edu*. It includes the Astfinder page, which will, if you supply it with your location and a desired time, generate a printable finder chart for any known asteroid.

Planetarium software packages such as *TheSky*, *SkyMap*, *Guide*, *MegaStar*, or *Starry Night Pro* access downloadable catalogs of asteroid orbits to plot selected asteroids on screen and also to generate finder charts.

## Asteroid science

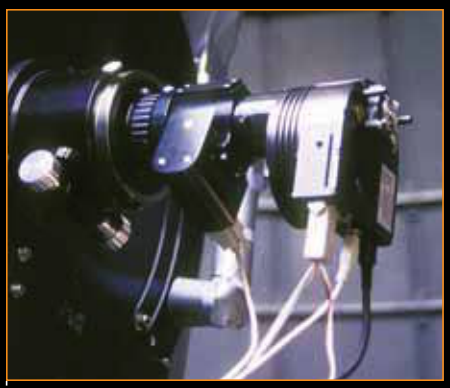
You can forget about trying to discover new asteroids at the eyepiece — the last visual discovery of an asteroid was in 1923. In fact, discovering asteroids is becoming increasingly

### /// GET STARTED HUNTING ASTEROIDS

An amateur astronomer who wants to make contributions to the study of asteroids must be equipped with a CCD camera, a telescope that will track the sky and point to celestial coordinates on command, a computer, and appropriate software. It also is necessary to be awarded a site code by the MPC. The Minor Planet Center will assign a site code to your location (for example: 701 Junk Bond Observatory; 699 Lowell Observatory-LONEOS; 036 Castel Gandolfo; etc.) after you submit — in the required format — a set of accurate position measurements for several asteroids whose orbits are well known.

The MPC's web site contains details on how to qualify your observatory for a site code, along with an abundance of information to help you get started doing asteroid science. Find it on the Internet at *cfa-www.harvard.edu/iau/mpc.html*. Click on "Guide to Minor Body Astrometry."

Another good resource is the Minor Planet Mailing List (MPML), on the Internet at *groups.yahoo.com/group/mpml*. This group comprises a worldwide network of both professional and amateur asteroid specialists. A few months lurking on the MPML is like a crash course in asteroid hunting.



AN SBIG ST-8 CCD camera attached to the author's 20-inch (0.5-meter) Ritchey-Chrétien Cassegrain reflector is used at Junk Bond Observatory. Today, asteroid searches are "all CCD." The last asteroid discovery made by looking through a telescope was in 1923. DAVID HEALY

### /// THE 20 BRIGHTEST ASTEROIDS FROM MARCH 2005 TO MARCH 2006

| Date | Asteroid name | R. A. (2000.0) | Dec. (2000.0) | Magnitude |
|---|---|---|---|---|
| March 23 | 2 Pallas | 12h22m | 9°18' | 7.1 |
| March 27 | 10 Hygiea | 12h05m | –6°53' | 9.3 |
| March 30 | 29 Amphitrite | 12h32m | –5°52' | 9.2 |
| April 30 | 15 Eunomia | 14h07m | –30°26' | 9.8 |
| May 8 | 1 Ceres | 15h10m | –8°13' | 7.0 |
| May 18 | 14 Irene | 15h30m | –10°12' | 9.0 |
| June 3 | 7 Iris | 16h48m | –23°23' | 9.2 |
| June 18 | 18 Melpomene | 17h53m | –7°46' | 9.5 |
| July 19 | 42 Isis | 20h18m | –30°06' | 9.2 |
| July 24 | 39 Laetitia | 20h10m | –10°04' | 9.6 |
| Aug 24 | 20 Massalia | 22h10m | –10°16' | 9.7 |
| Oct 25 | 89 Julia | 1h12m | 38°57' | 9.4 |
| Nov 4 | 19 Fortuna | 2h42m | 15°07' | 8.9 |
| Dec 7 | 16 Psyche | 5h04m | 18°04' | 9.4 |
| Dec 9 | 11 Parthenope | 5h06m | 17°13' | 9.8 |
| Dec 9 | 3 Juno | 4h49m | –2°27' | 7.6 |
| Dec 21 | 60 Echo | 5h51m | 16°25' | 9.9 |
| Jan 5 | 4 Vesta | 7h09m | 22°51' | 6.2 |
| March 2 | 9 Metis | 11h03m | 16°35' | 9.1 |

difficult even for well-equipped amateurs who operate under dark skies. The professional surveys, LINEAR in particular, have swept up virtually all relatively bright asteroids. An amateur has to be able to image objects at least as faint as magnitude 19.5 in order to have a reasonable chance at making discoveries.

Although finding a new space rock is ego boosting, discovery is not the only scientific contribution an amateur can make. Although less exciting, follow-up, for example, is of great value. Many known asteroids carrying only provisional designations from the MPC have not been well observed (or not observed at all) since their discovery. Amateurs can provide astrometry — precisely timed position measurements — for these bodies. Follow-up measurements of MBOs help professional astronomers refine poorly known orbits. In the case of following up NEOs — a more challenging endeavor because NEOs are generally faint and fast-moving — you may be doing your bit to ensure humankind's survival.

Photometry, measuring changes in an asteroid's brightness, is a more demanding process than astrometry. But because observers can obtain useful measurements even on bright asteroids, the amateur photometrist need not have a large telescope or dark sky. Photometry often is used to determine an asteroid's rotational period, which, in turn, gives clues to its size and shape.

## What you'll need

To date, my observatory (Junk Bond Observatory in southeastern Arizona) has been responsible for 116 asteroid discoveries. The discoveries have resulted from a partnership between Jeff Medkeff, a computer consultant and a developer of astronomical software, and me. Perhaps oversimplifying a bit, Jeff provides the brains, and I provide the scope.

You no longer need high-level computer savvy, however, to do important asteroid work. The power and user-friendliness of asteroid-observing software have increased exponentially in the last few years. At present, any amateur astronomer who can operate a laptop, a CCD camera, and a go-to telescope can become an imager of asteroids.

Listed resources, along with some hard work and patience, will allow you to accomplish what only a few professional observatories were capable of a decade ago.

Check positions of bright asteroids; use Star Dome at www.astronomy.com/toc

### /// ASTEROID SOFTWARE

Software running under the *Windows* operating system has automated these formerly tedious manual tasks:

- Scripting the telescope to take sets of images of the same sky area
- "Platesolving" — matching a given number of stars in the image with the same stars in a digital star catalog
- Aligning the sets of images so the identified stars are in register
- Blinking the images in sequence so objects that move in the interval between exposures — possible asteroids — can be detected and their positions recorded
- Generating an observing report in the required MPC format

Among the excellent sky-search programs are Bob Denny's *Visual PinPoint* and *ACP Observatory Control Software*. Find them on the Internet at *dc3.com*. We also use Jeff Medkeff's *Ultimate Telescope Scripting* software (*www.roboticobservatory.com*) and Diffraction Limited's *MaxIm DL* (*www.cyanogen.com*) for camera control. Also, check out Software Bisque's planetarium software *TheSky* and *CCDSoft* at *www.bisque.com*. *CCDSoft* offers CCD camera control, image processing, and data reduction.

JUNK BOND OBSERVATORY near Sierra Vista, Arizona, is where the author and his observing partner, Jeff Medkeff, have discovered 116 asteroids. DAVID HEALY

Ancient Greeks and Romans captured celestial images on their coins, letting us see the sky through their eyes. /// RICHARD JAKIEL AND JERRY ARMSTRONG

# Striking ancient skies

Back a couple of millennia, before television and *The Simpsons*, what did people watch after they ate supper and did the dishes? The sky, of course! (It was the only thing lit up.) ☾ Indeed, looking up at the heavens dates back to early civilization. Astronomy and astrology had a tremendous impact on Greco-Roman culture. Many ancient coins of that era commemorated important astronomical events.

The design and minting of coins began during the reign of King Ardys between 643 and 630 b.c. in the Greek state of Lydia — located in modern Turkey. At first, coins were little more than rounded metal disks, or "flans," of precious or semi-precious metal imprinted with simple designs. Both the Greeks and the Romans used coins, not only as currency, but as propaganda.

ATHENS produced this silver *tetradrachm* to commemorate the Athenian victory over the Persians in the Battle of Marathon (490 B.C.). Known as "The owl" because of Athena's owl on the reverse, this coin was one of an estimated 9 million struck during a period of 3 centuries. It is one of the most celebrated ancient coins. *(ALL COINS SHOWN AT ACTUAL SIZE UNLESS OTHERWISE NOTED.)* MARC BREITSPRECHER

The first silver coins used in the Roman Republic were struck during the third century B.C. They were intended to facilitate trade with the Greek colonies of southern Italy. The Romans also used the coins to disseminate the emperor's image throughout the empire.

Richard Jakiel *is an avid deep-sky observer who recently got caught up in ancient-coin collecting.* Jerry Armstrong *has observed more than 200 comets and is the codiscoverer of the 1994 supernova in M51.*

## Astronomy events on coins

An early example of a coin including astronomical objects is the silver Athenian *tetradrachm*. On the front — or "obverse" — is the goddess Athena's head. On the back — "reverse" — is an owl with a small crescent above its shoulder.

The crescent signifies the Moon phase during the Battle of Marathon (490 b.c.), when the Athenians defeated the Persians.

The difficulty in dating relics from much of the Greek era makes the association of any of these coins with specific astronomical events a daunting task. Such is not the case for most Roman coins.

From the minting of the Roman *denarius* in 211 b.c., through the western empire's fall in a.d. 476, and Byzantium's defeat in 1453, the dating of coins often is a straightforward affair. These coins commemorated various celestial sights. The ties that bound the course of human affairs with the heavens are clear.

## Eclipses

The Sun's disappearance and corresponding onset of darkness was a terrifying event for people in ancient times. For example, Herodotus, the first Greek historian, records the Battle of Halys between the Lydians and Medes ground to a halt as a result of the fear generated by an eclipse (astronomers generally regard May 28, 585 b.c., as the date of the eclipse).

In most cases, an eclipse was taken as a bad omen, and it wasn't something to be celebrated or commemorated. However, the Roman government used the annular-total eclipse of November 11, 120 b.c., to advance its agenda. The eclipse path cut across central Spain, near land occupied by the recently conquered Narbonese Gauls. The Romans used this astronomical omen to promote the region's colonization and issued silver denarii to commemorate the occasion.

THIS ROMAN COIN with Emperor Julian II, the Apostate, on the obverse commemorates the conjunction when Venus and Mars were so close together in the sky May 4, A.D. 360, they appeared to merge into one bright "star." MARC BREITSPRECHER

## Conjunctions and occultations

Noted astronomer, mathematician, and numismatist Marshall Faintich cites a close

THE ROMANS commemorated the close conjunction of four planets and the Moon on this coin. On the reverse, note the three stars and a crescent above the two-horse chariot. Venus, Mars, and Jupiter were close together in the sky, while Mercury was just below the horizon after sunset June 17, 109 B.C. RICHARD JAKIEL

conjunction of the Moon with three bright planets (Venus, Mars, and Jupiter) shortly after sunset June 17, 109 b.c. On the reverse of a contemporary denarius, this event is represented by a crescent surrounded by three stars. Below a *biga* (a two-horse chariot) sits another star — presumably symbolizing Mercury, which was nestled below the horizon then.

Another conjunction is associated with a large bronze coin issued under Julian II, the Apostate — the last pagan Roman emperor. The reverse features a large bull (Taurus) with a large "star" above it. According to Faintich, Venus and Mars would have been so close together May 4, a.d. 360, they would have "merged" visually to form a single star to the naked eye.

Many Roman coins have a crescent and star(s) theme. Some, like the denarius of L. Lucretius Trio in 76 b.c., have been linked to lunar occultations of the Pleiades.

THE JULIUS CAESAR COMET of 44 B.C. shone in the daytime sky during Julius Caesar's funeral games. The Romans interpreted the sighting of this comet as Caesar rising to the heavens. This "comet coin" was created in 18 B.C. by Augustus Caesar. RICHARD JAKIEL

However, the symbolism on many coins is unclear. Coins depicting seven stars and a crescent may represent other occultations of the Pleiades. Because some coins show between one and five stars, other explanations have been sought. One theory is these stars represent conjunctions of the Moon with the planets known to the ancients.

An alternate theory associates these markings with solar eclipses, where a single star and crescent depict the phenomenon of Baily's beads (the points of sunlight sometimes seen along the Moon's edge before or after totality in a solar eclipse).

## Visitors from space

Historically heralded as a harbinger of change and/or an evil omen, a comet can be an awe-inspiring sky spectacle. The famous Julius Caesar Comet of 44 b.c. was first recorded by Chinese astronomers from May to June, and later was observed by the Romans in July. Lately, this comet has been the focus of modern scientific research.

THE ROUND OBJECT carried by the chariot on this coin is a meteorite. At the time, the black stone — iron meteorite — was believed to be a messenger of the Sun god, Heliogabalus. Roman Emperor Elagabalus transported the stone from Emesa to Rome to make the deity the empire's supreme god. DON ROSE

Enlarged 260%

According to historical sources, the comet appeared for at least 7 days during Julius Caesar's funeral games. It was located below Cassiopeia and was visible during the *daytime* as a reddish "hairy star" in the northeastern sky. Authors John T. Ramsey and A. Lewis Licht suggest Caesar's comet coma became as bright as –7 magnitude July 23, 44 b.c. The Romans associated this object's appearance with Caesar's ascent into the heavens.

In 18 b.c., Augustus Caesar commemorated the event with the beautiful "comet coin." On the reverse is an eight-ray "star" astride the words *Diuus Iulius*, or "Divine Julius."

The fall and subsequent recovery of a meteorite had special significance for the Romans. They worshipped these "stones" as messengers or manifestations of the gods. The black stone of the Sun god (Baal) temple located in Emesa (Syria) is one of the most famous.

The young, eccentric emperor Elagabalus was the high priest of the Sun god. He removed the iron meteorite from Emesa and transported it to Rome by chariot.

He wanted to make the Sun god the empire's supreme god under the name *Deus Sol Invictus* (God the Invincible Sun). Many coins from Elagabalus' short reign display this black stone as an oval object set on a cart, sometimes being pulled by horses.

## Guest stars

Bright "guest stars" — novae and supernovae — were significant also. One particularly bright nova occurred in 2 B.C. during the reign of Augustus, Rome's first emperor.

THE NOVA OF 2 B.C. is represented on the obverse of this coin as a hard-to-see, six-figure star above Augustus' head. The reverse of a variant of this coin shows an eagle perched on a globe with a star over its shoulder. Note that Earth is represented by a globe on this ancient coin. RICHARD JAKIEL

It appeared in the constellation Aquila the Eagle and was observed by both the Romans and the Chinese. Years later, Emperor Tiberius commemorated the event with a series of coins. One type features a six-point star above Augustus' head, while the reverse of another variant has the star above the shoulder of an eagle standing on a globe (possibly Earth).

The brilliant supernova of A.D. 1054, whose remains now form the Crab Nebula (M1), was observed from many parts of the globe. Its brightness peaked July 4 and was at least –6 in apparent magnitude. In the eastern Roman (Byzantine) Empire, the rare gold coin *histamenon nomisma* of Constantine IX has two stars on the reverse, which many think represent the supernova.

## Making your own collection

Many ancient astronomical coins can be picked up for the price of an inexpensive eyepiece, although rarer ones can cost hundreds of dollars. Bronze "star and crescent" coins are generally easy to find, while Caesar's "comet coins" can command premium prices. Ancient-coin dealers, large coin shows, and on-line auctions are resourceful places to look for these astronomically significant pieces of history.

Thousands of coin varieties exist, and many haven't been adequately analyzed or even cataloged. By starting your own collection, perhaps you can make important discoveries.

Besides, it's a lot more constructive than watching *The Simpsons*.

Learn how to start your own coin collection at www.astronomy.com/toc

PROFILE

Walter Haas bridged the gap between amateur and professional astronomers when he founded the Association of Lunar and Planetary Observers in 1947. /// BY TRUDY E. BELL

# A planetary pioneer

## Walter Haas has observed the Moon

and planets for more than 7 decades. But it's what he did away from the eyepiece that's left an indelible mark on astronomy. More than a half century ago, he founded the Association of Lunar and Planetary Observers (ALPO), which coordinates amateur observations of solar-system objects. What began as an informal network of shared data is, today, a worldwide organization uniting amateur and professional astronomers. And it all goes back to an incredible gift.

In 1934, amateur astronomer John H. Chase offered 17-year-old Haas, a budding amateur astronomer in New Waterford, Ohio, an extraordinary choice: an entire year of college free or 8 weeks in Jamaica to work with renowned lunar and planetary observer William H. Pickering.

Which did he choose?

"Being young and foolish — a year at college would have been of far greater economic value — I chose Jamaica," Haas recalls. The following May, he was on a banana boat plying through the deep blue Caribbean toward the British West Indies.

WHILE A STUDENT at Mount Union College in Alliance, Ohio, Walter Haas honed his observing skills and studied the solar system in earnest. He spent countless hours peering through the 10-inch Saegmuller refractor in the school's Clarke Observatory, seen here in its original 1923 building. MOUNT UNION COLLEGE

### Tropical apprenticeship

Although Jamaica is hardly famed as an astronomical mecca, it has one major underrecognized asset: exquisitely steady seeing. Pickering's private Woodlawn Observatory, founded in 1911 on a former coffee plantation 2,000 feet (610 meters) above Mandeville's haze and dust, featured a 12.5-inch Newtonian reflector housed in a roll-off shelter.

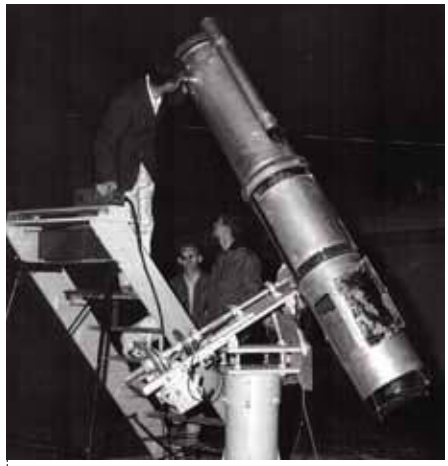
By day, Haas devoured books in the well-stocked astronomical library or studied Pickering's observing notes from the night before. After sundown, he assisted 78-year-old Pickering and absorbed the discipline of the veteran observer's nightly practices: rating the atmospheric seeing, sketching what he saw while still at the eyepiece, and training his eye to recognize details and subtle shades of color.

In short order, Haas was observing the Moon and planets solo. The summer internship was so successful, it was extended from 8 weeks to 15. By late August, Haas was dedicated to the solar system. He also had become friends with Pickering's secretary, Beryl "Peggy" Godfrey, who, years later, he married.

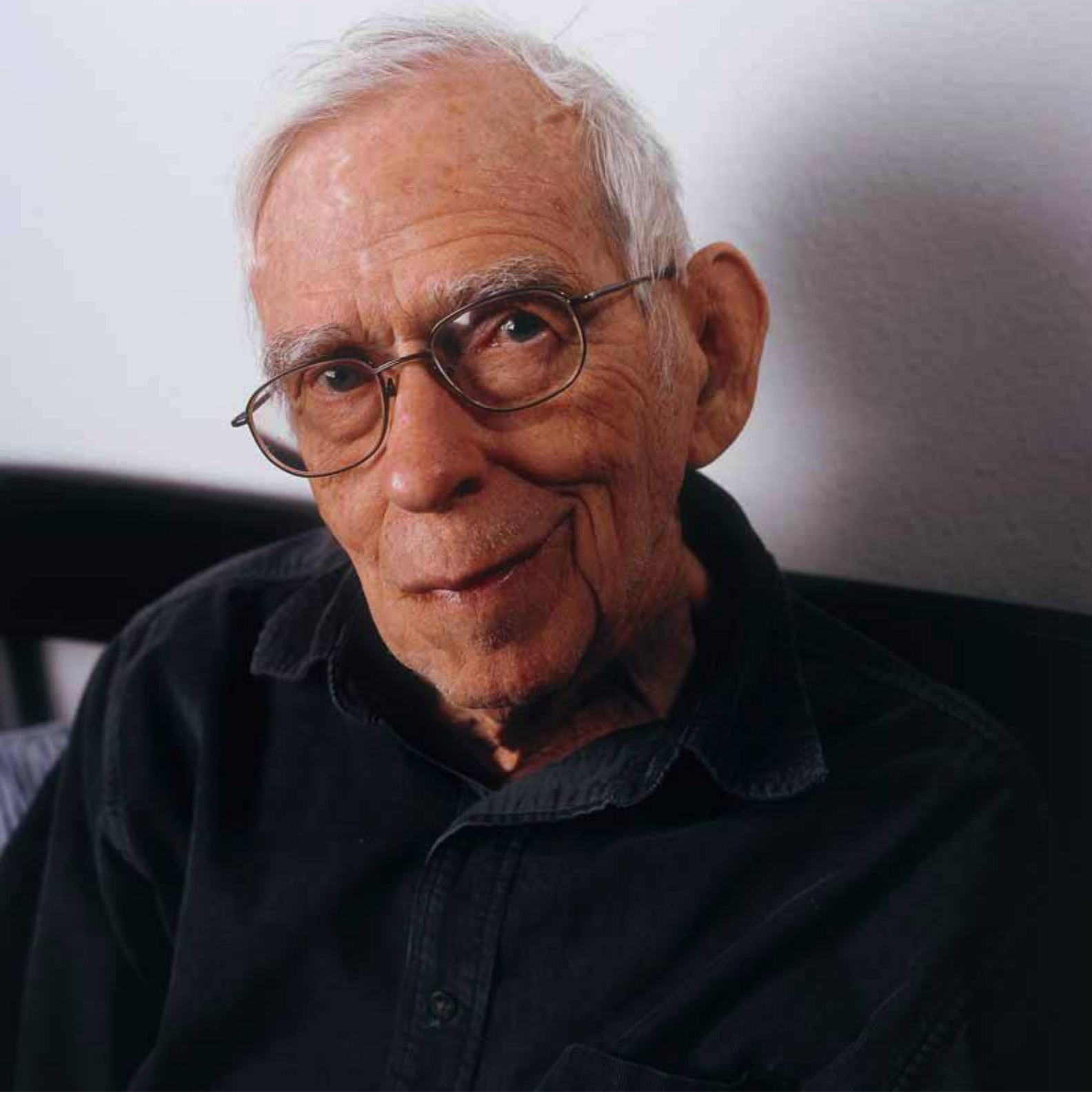
### An early call for action

A month after his return to the States, Haas received a full scholarship to Mount Union College, a small, private, liberal-arts institution in Alliance, Ohio. There, he earned his bachelor's degree in mathematics in 3 years. He also was essentially the sole user of the 10-inch Saegmuller refractor in the college's Clarke Observatory. With it, he embarked on his first serious studies of Mercury, Venus, Jupiter, and Saturn in 1936; he estimated the relative intensity — or brightness — of features suspected of changing.

As an undergraduate, Haas questioned the view widely held among professional astronomers in the United States that, to quote Simon Newcomb in *Astronomy for Everybody* (1926), the Moon was "a world which has no weather and on which nothing ever happens." In the 1930s, only variable stars and meteors were regarded as fields where amateurs could make scientific contributions because professionals had large telescopes and could do astrophotography.



AN INSPIRATION TO MANY, Walter Haas peers through the eyepiece of his 12.5-inch Newtonian reflector in the 1960s. The two teenagers waiting for a view are among the many scientists influenced by ALPO: Gordon Solberg, a former planetary astronomer (left), and Steve Larson, director of the Catalina Sky Survey at the Lunar and Planetary Laboratory in Tucson, Arizona. DENIS MILON



WALTER HAAS founded the Association of Lunar and Planetary Observers in 1947 with the goal of enriching humans' knowledge of "our sister-worlds." Today, ALPO boasts more than 550 members in 25 countries who collect data about planets, moons, and other solar-system bodies. CHRIST CHÁVES

So it was in the *Journal of the Royal Astronomical Society of Canada* (*JRASC*) that Haas published a September 1938 article recounting his observations of brightness changes around major lunar craters. He questioned whether the changes were physical or chemical alterations rather than simply changes in Sun angle. "The Moon has been too much neglected in recent years," he asserted. "An organized group of careful and persistent amateurs could do much of value on the Moon," even with small telescopes. And with that, Haas began to build an informal network of regular observers with whom he compared observations through long-hand letters and painstakingly hand-copied drawings.

## An astronomical career

After finishing his course work at Mount Union, Haas took extra classes at the Case Institute of Applied Science (now Case Western Reserve University) in Cleveland,

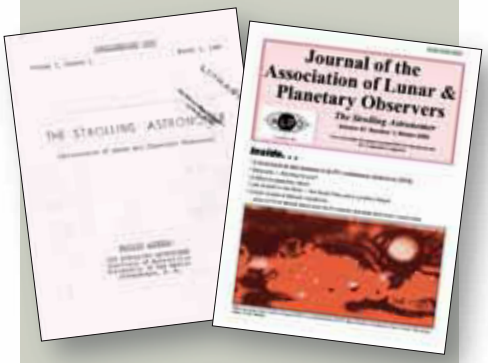
then matriculated at the Ohio State University, earning a master's degree in mathematics in 1941. His thesis, on the mathematical theory of meteoroid orbits, was supervised by Lincoln La Paz, who later founded the Institute of Meteoritics at the University of New Mexico (UNM).

In 1941, Haas went to the University of Pennsylvania as an assistant to astronomy professor Charles P. Olivier, founder of the 3-decade-old American Meteor Society. By day, Haas trained Navy aviation students in celestial navigation. By night, with unlimited access to the observatory's 18-inch Brashear refractor, he continued the phenomenal pace of visual observing he had sustained through college and graduate school: more than 450 hours per year on average.

### /// ALPO TODAY

Nearly 6 decades after its founding, ALPO boasts some 550 members worldwide. Organized into "sections," each dedicated to its own planet, other body, or event (such as eclipses), the association is open to all astronomers regardless of skill level.

The group offers a training program to ensure the collected data's reliability. Data and other communications are published in the *Journal* and, once a year, members gather to share their findings in person. For more information, or to join ALPO, go to *www.lpl.arizona.edu/alpo*.




ALPO'S JOURNAL, *The Strolling Astronomer,* has come a long way since its first issue, (left) published in 1947. PRINTED COURTESY OF ALPO

*The Strolling Astronomer,* Volume 1, Number 1, contained Walter Haas' appeal for John Q. Amateur to submit lunar and planetary observational data for distribution to the scientific community. Today, the journal is published quarterly in print and in electronic format. — *Laura Baird*

HELD IN TUCSON, Arizona, ALPO's first independent convention in 1966 drew together amateur and professional astronomers. The association continues to meet yearly. ALPO founder and director emeritus Walter Haas is on the far right wearing a dark jacket in the third row. STEVE LARSON

In 1942, Haas published the longest work of his career — a tour-de-force article totaling 76 pages in four successive issues of *JRASC* titled "Does Anything Ever Happen on the Moon?" based on his lunar observations from 1935–41.

Although the meticulously supported article was quiet and courteous in tone, the work was virtually a manifesto with the avowed intention "to arouse interest in a neglected branch of astronomy." It concluded, "I urge all amateurs (and professionals, also) interested in lunar matters to communicate with me. Blanks for recording notes and drawings and instructions for so doing will be furnished free of charge. The cooperative efforts of an association of lunar observers can greatly further our knowledge of the Moon."

His interest in meteors awakened by La Paz and Olivier, Haas began searching for evidence of meteoroids hitting the Moon. La Paz had calculated a 10-pound meteoroid striking the airless lunar surface should vaporize with an impact flare brilliant enough to be visible to the naked eye from Earth.

In August 1943, Haas reported in *Popular Astronomy* that, after spending 1,500 hours over 3 years observing the Moon, he and two other observers had spotted 15 momentary bright specks ranging from 5th to 14th magnitude. Haas' conviction was vindicated 56 years later, when Brian Cudnik of Houston and others visually observed flashes on the dark part of the Moon during the Leonid meteor shower of November 1999, flashes confirmed on videotape by David W. Dunham — founder of the International Occultation Timing Association (IOTA).

After World War II, La Paz — who had become the head of the UNM mathematics department — hired Haas. Haas taught at UNM from 1946 to 1950, when he was appointed as a mathematician at White Sands Missile Range. In 1954, he became a mathematician at New Mexico State University's Physical Sciences Laboratory in Las Cruces, where he remained until his retirement in 1983.

## The founding of ALPO

On March 1, 1947, while at UNM, Haas mailed out a mimeographed, 6-page newsletter titled *The Strolling Astronomer* to dozens of his long-time correspondents and observing colleagues, as well as to all major science publications. Inside was a three-paragraph editorial that, with Haas' characteristic low-key humor, began: "There exist amateur astronomers; there exist the telescopes they have built; there exist the Moon and the planets. This leaflet is an attempt to persuade the party of the first part to use the party of the second part to increase knowledge of the party of the third part."

The goal was to show "ways in which John Q. Amateur can profitably study our sister-worlds" and report findings. "We propose to send you six future monthly mailings for one dollar … how about it?"

That he fully intended the newsletter to grow into something bigger is clear: The unadorned cover of the first issue was subtitled "Association of Lunar and Planetary Observers" and labeled "Volume I, Number 1." And grow it did. By the second issue, in April, ALPO had 21 members; in May, it had 41 members, including Clyde Tombaugh (discoverer of Pluto) and half a dozen other astronomical notables.

Within 3 years, the number of drawings and observations flooding into ALPO was so great that Haas — who had his university day job — could no longer analyze them all himself, nor edit and produce *The Strolling Astronomer* single-handedly. The mechanics of publishing were delegated to

an outside agency, and ALPO itself was reorganized with "coordinators" for each planet who collated and reported on the observations received. By 1953, ALPO boasted 350 members worldwide. In 1956, it began cohosting annual conventions with the Western Amateur Astronomers and the Astronomical League.

For its first 4 decades, ALPO was what Haas calls "delightfully informal," with no legal structure. But in 1985, when 68-year-old Haas was hospitalized for a back problem, *The Strolling Astronomer* almost ceased publication. To ALPO's associate director, John Westfall, professor of geography at San Francisco State University, that turn of events was a wake-up call. Westfall flew to Las Cruces to visit Haas in the hospital and urge that ALPO be incorporated as a not-for-profit organization.

## ALPO's legacy and future

"You could say the entire thrust of NASA's planetary exploration has been influenced by the Association of Lunar and Planetary Observers because a number of the scientists running the missions now got their start through ALPO," declares David H. Levy, science editor for *Parade* magazine, discoverer of 21 comets, and author of 30 astronomy books. Dale P. Cruikshank, a science-team member for the Cassini mission and others, recalls Haas could refuse an article submitted to *The Strolling Astronomer* "in such a graceful style that it didn't feel discouraging."

This hints at another aspect of Haas' character: his unflagging rigor in standards for both data and logical argument, even from amateurs. "That's why the journal is so good — he goes through every observation and checks the numbers," says Donald C. Parker, ALPO's executive director from 1998–2000 and 2002–2003. "He's tough. He raises the tone of a meeting. You don't make things up because he asks pointed questions." Pointed maybe, but he asks mildly, as if making a respectful suggestion. Recurring words people use to describe Haas' personal manner are "kind," "gentle," "patient," "courteous," and "encouraging."

Trudy E. Bell *is a science and technology journalist. Walter Haas published her first article outside a campus newspaper in the June 1970 issue of* The Strolling Astronomer*; it was her observations of the March 7 total solar eclipse.*

RECOGNIZED FOR OUTSTANDING SERVICE
For his founding of ALPO and decades of encouraging observers the world over, Walter Haas has been recognized with numerous awards from local, regional, and national organizations including: the Astronomical League's prestigious League Award (1952) and Leslie C. Peltier Award (1982), the Western Amateur Astronomers' G. Bruce Blair Award (1955), and the Astronomical Society of the Pacific's Amateur Achievement Award (1994). CHRIST CHÁVES

"Encouraging" because opportunities for amateur contributions to lunar and planetary observing abound. The instrumental playing field between professionals and amateurs has been leveled notably by the advent of relatively inexpensive, high-resolution CCDs, plus software that selects and "stacks" images taken at instants of fine seeing. By this technique, in 2003, "amateurs got images of Mars that were nearly as good as the billion-dollar Hubble Space Telescope," notes Charles Wood, an affiliate scientist at the Planetary Science Institute in Tucson, Arizona.

Amateur visual observations are valued, too. According to William K. Hartmann of the Planetary Science Institute, professional astronomers today rely on amateurs to sound the alert about changes on the planets (such as dust storms on Mars or new spots on Jupiter) because "professionals can't commit the largest telescopes to monitoring programs."

## Returning the favor

Throughout the years, Haas' commitment to observing and to the organization he founded have been extraordinary. Until sidelined by a broken hip in June 2004 (after observing the transit of Venus in England), Haas continued his keen-eyed vigil of the Moon and planets. He logged an hour or 2 about 8 nights a month atop the ladder at the eyepiece of his 12.5-inch Newtonian reflector.

Only now, his observations are joined with hundreds of others. His 1947 vision for ALPO, to increase knowledge of "our sister-worlds," continues to be realized by amateur astronomers worldwide. This, like his benefactor before him, is Haas' own incredible gift to astronomy.

With more than 5,000 times the light-gathering power of your eye, this monster telescope delivers great views. /// BY MIKE MARCOTTE

# Meade's new 14-inch SCT: an instant classic

Twenty-four years ago, Meade entered the Schmidt-Cassegrain telescope market with its Model 2080 8-inch SCT. This marked the start of not only the tremendous growth of Meade but also of the amateur telescope market. Today, Meade offers the LX200GPS-SMT line of fully automated go-to and Global Positioning System (GPS)-equipped telescopes with apertures from 7 to 16 inches. And the LX200GPS-SMT14, with its high-quality optics, mechanical excellence, accurate computer control, and large aperture, has arrived to make a statement.

## Think big

The 14-inch LX200GPS-SMT is an f/10 system with a focal length of 3,556 millimeters. The optical-tube assembly is mounted on a heavy-duty, twin-fork mount directed by the AutoStar II hand controller. AutoStar II sports a database of 145,000 objects, a 200-object user-defined library, and a terrestrial landmark library.

The menu features event items such as the times of sunrise, sunset, moonrise, and moonset. You also can find dates of Moon phases, meteor showers, equinoxes, and solstices.

THE AUTOSTAR II HAND CONTROLLER contains a 145,000-object database. It also allows you to input additional celestial objects and terrestrial landmarks. *ASTRONOMY*: JAMES FORBES

Other options include standard and user-defined tours of the night sky. AutoStar II also gives you the option of choosing among 200 custom tracking rates, including sidereal, lunar, and seven alignment modes, as well as an integrated GPS.

The system is menu-driven and user-friendly, especially if you take some time to view the menu-options page in the manual Meade supplies with the telescope. In fact, I reviewed that page before every observing session to refresh my memory of the time-saving features available. This makes my observing sessions more efficient.

This telescope comes with Meade's standard optical surface coating. The optional Ultra-High Transmission Coating group (UHTC) costs an additional $350 for the 14-inch LX200GPS-SMT. Meade's tests show the UHTC, when averaged over the entire visible spectrum, increases light transmission to the telescope focus by about 15 percent. The telescope I tested came with the UHTC, and although I did not have a non-UHTC 14-inch scope for comparison, I did have the opportunity to compare two 8-inch LX90 telescopes, one with the UHTC and the other without. The UHTC showed an increase in brightness across a full range of celestial objects.

THE CONTROL PANEL of the LX200GPS-SMT has inputs for the handbox controller, an external computer, and an autoguider — 12 volt DC power is also supplied. *ASTRONOMY*: JAMES FORBES

## First impressions

When I take a telescope out of the box and set it up for the first time, I look closely at the workmanship and detail of the whole instrument to get an idea of its quality. Next, I run the drive motors at several speeds in all directions for a few minutes. This gives me an overall feeling for how consistently the drive system operates.

The mounting fork, body, and tripod of the test 14-inch LX200GPS-SMT were hefty, sturdy, and well-fitted. The motors sounded strong, consistent, and smooth.

I used this telescope for several weeks under many conditions and my first impression was reinforced.

MEADE'S LX200GPS-SMT is a large telescope, but it can be transported and set up anywhere. Compare its size to Meade's 5-inch ETX125 (right). *ASTRONOMY*: JAMES FORBES

MEADE'S AUTOSTAR SUITE is a software package that helps you both acquire images and process them. *ASTRONOMY*: JAMES FORBES

Several other things indicated this telescope was as tough and solid as it looked. It was in perfect collimation right out of the box and stayed that way even after riding hundreds of miles in my pickup — many of those miles over rough dirt roads.

The performance of the computer and electronics also proved reliable. AutoStar II's Automatic Alignment mode is easy to understand and operate. In this mode, AutoStar performs several operations in addition to locating the telescope's position with the integrated GPS. It automatically finds "home" position, which tells the system the telescope's limiting positions to avoid cord tangles and over-rotation.

It locates true north by sensing magnetic north and comparing that to the GPS location. AutoStar II then levels the optical tube using a tilt-and-tip method at three different compass points.

While the telescope is performing these operations, it rotates and swings in several directions — an amusing display for an audience at a star party.

Once aligned, the telescope's go-to operation was almost flawless. Only once did the go-to function have trouble placing the selected object in the field of view. At that point, I went into the "train drive" mode in AutoStar II. Training the drive raises the computer-pointing accuracy. After that, I had no problems. Another feature that enhances the go-to drive is "Smart Mount Technology" (SMT). In short, this function is a 40-star alignment process.

This operation is lengthy and involves an illuminated reticle eyepiece. Also, SMT is accurate only for one location. If you perform SMT, however, the pointing will be almost perfect.

THE ZERO IMAGE-SHIFT MICROFOCUSER allows precise focusing without annoying mirror shift. *ASTRONOMY*: JAMES FORBES

## Observing with the 14-inch

The 14-inch LX200GPS-SMT's optical performance was outstanding. I observed mostly with 1¼" eyepieces that have focal lengths from 8mm to 40mm, including the 26mm eyepiece that comes with the telescope.

On a couple of occasions, I used 2" eyepieces, including Meade's 14mm. If you plan on owning a telescope bigger than 8 inches, invest in a good set of 2" eyepieces.

Meade's microfocuser took some time to get used to, but once I did, I could sharpen the images better than with the standard focusing knob. Even in a light-polluted area like my backyard, I was impressed with the contrast and sharpness of the 14-inch LX200GPS-SMT's images, even to the edge of the field of view.

I observed objects ranging from planets to distant galaxies and was pleased with the image detail and quality. Saturn and Jupiter were excellent targets. Both showed fine detail in their bands and belts.

On a couple of occasions, I observed the shadows of Jupiter's moons — well defined and easily seen — as they crossed the planet's cloud tops. In September, in the early morning, I enjoyed terrific views of Saturn.

The Cassini Division appeared as a strong black line, which was no surprise. What did surprise me was how defined the dark belts on Saturn's surface were.

Saturn's equatorial region even showed a hint of color. Quick looks at Uranus and Neptune revealed good coloration through the 26mm eyepiece in a light-polluted sky.

Moving to the outer reaches of space, I spent some time searching for faint galaxies in Boötes and Canes Venatici. I was surprised I could see structure in 13th-magnitude galaxies.

The NGC 5416 group was faint, but I was able to pick out most members, especially with averted vision. Several galaxy groups in Boötes can be picked up in the field of view of the 26mm eyepiece. My interest was drawn to some of the brighter, more defined galaxies in that area, such as NGC 5248, which has a bright center and spiral arms reaching out into an oval halo.

THE 14-INCH LX200GPS-SMT can accomodate the largest eyepieces with no balance problems. *ASTRONOMY*: JAMES FORBES

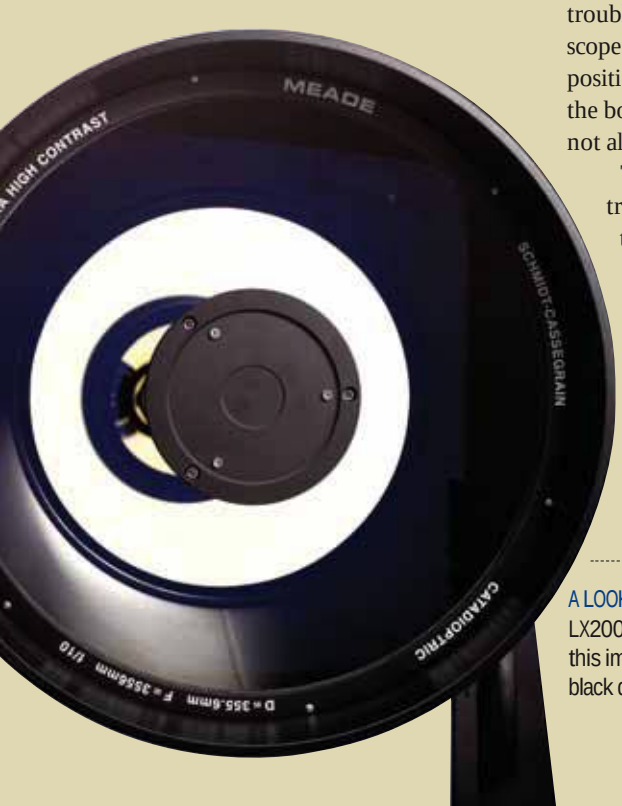
Mike Marcotte *is a retired firefighter and dedicated astronomer who observes with his equally dedicated wife, Mary, in El Paso, Texas.*

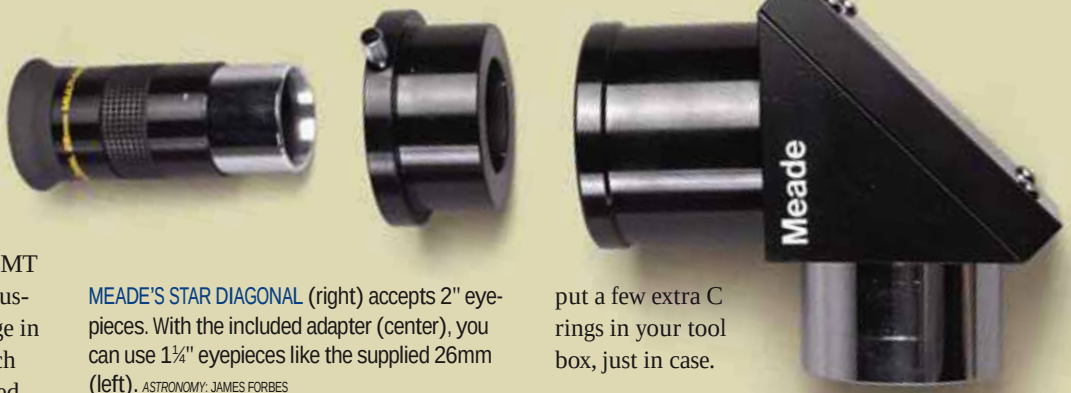
Two other eye-catchers were 10th-magnitude NGC 4244 and magnitude 8.5 M106 in Canes Venatici. The spindle structure of NGC 4244 and the spiral structure of M106 were easy to discern.

Some other great objects I was able to enjoy with the 14-inch LX200GPS-SMT were planetary nebulae and globular clusters. Planetaries that appear as a smudge in an 8-inch scope jump out in the 14-inch with depth and color. Globulars I viewed through this scope gave a deeper meaning to the familiar description "like diamonds on black velvet." Of course, no observing session would be complete unless I spent some serious time glued to the eyepiece observing double stars. I viewed a number of close doubles with the magnification pumped up as high as 404x with a Meade 8.8mm UWA eyepiece. It was satisfying to resolve companion stars impossible to see with a smaller telescope.

One other object I observed was the Moon. I mention this because the AutoStar II comes with a special "Moon" menu. Once you have gone into the "Moon-SYNC" mode, the go-to drive is precise enough to point to individual lunar features.

The 14-inch LX200GPS-SMT also comes with the AutoStar Suite, which includes Meade's Lunar Planetary Imager and a software package. You can use the AutoStar Suite to guide the telescope from a notebook or desktop computer and to perform basic imaging of bright objects.




MEADE'S STAR DIAGONAL (right) accepts 2" eyepieces. With the included adapter (center), you can use 1¼" eyepieces like the supplied 26mm (left). *ASTRONOMY*: JAMES FORBES

## Is it portable?

The 14-inch LX200GPS-SMT is a big telescope. That may seem strange to say, but if you're not accustomed to large SCTs, then "size shock" can be overwhelming.

The box holding the telescope measures 52" by 32" by 24" and weighs more than 175 lbs. The tripod comes in a separate box.

Setting up the 14-inch LX200GPS-SMT is a two-person job. It is heavy and awkward to handle, and trying to place the scope on the tripod without help is inviting disaster.

Although this telescope is portable, it is best suited for a permanent location. I would transport the telescope only with the proper vehicle, such as a pickup or van, and I would make sure I have help handling it.

A few things about the 14-inch LX200GPS-SMT might cause small problems. You mount the telescope to its tripod with a single bolt that passes through the spreader plate and screws into the telescope's base. On several occasions, I had trouble aligning that bolt with the hole. The scope's weight made it difficult to adjust its position with one hand while trying to align the bolt with my other hand. If the bolt is not aligned properly, it can cross-thread.

The mounting-bolt is attached to the tripod with a "C" ring, which allows you to leave both the bolt and spreader plate attached to the tripod. I discovered these parts didn't allow the tripod completely to fold, which made it harder to store and transport.

The simple solution was to remove the bolt each time I stored or transported the tripod, but with so much handling, the C ring could break or be lost. So, it's a good idea to put a few extra C rings in your tool box, just in case.

A LOOK THROUGH the corrector lens of the 14-inch LX200GPS-SMT shows the primary mirror (white in this image) and the secondary mirror support (the black disk). *ASTRONOMY*: JAMES FORBES

## And the verdict is . . .

Overall, the 14-inch LX200GPS-SMT earned an excellent rating. My wife and I traveled thousands of miles with this scope, setting it up 15 times for a range of different events including astronomy-club gatherings in West Texas, public star parties in Arizona, short observing runs in our light-polluted city backyard, and several all-nighters on a dark, isolated hill in New Mexico. The loading and unloading and setting up and breaking down became tedious at times, but through it all, the telescope performed as advertised and provided us with views that were nothing less than spectacular.

### /// PRODUCT SPECIFICATIONS

**MEADE'S 14-INCH LX200GPS-SMT**

Telescope weight:
166 pounds; total with tripod: 225 pounds

Dimensions:
17" by 24" by 44"

Eyepiece:
Series 4000 26mm Super Plössl (137x)

Finder scope:
8x50mm

Mount:
Heavy-duty alt-azimuth fork, double tine

Also included:
AutoStar II control system, Smart Mount, 4-speed Zero Image-Shift Microfocuser, GPS alignment system with 16-channel GPS receiver, 2" star diagonal with 1¼" adapter, variable-height field tripod

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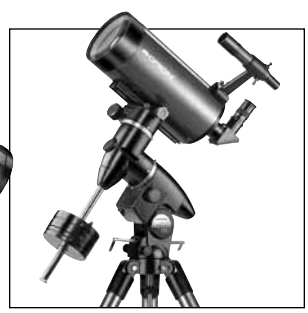

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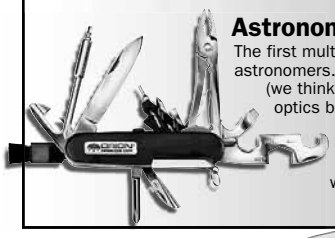

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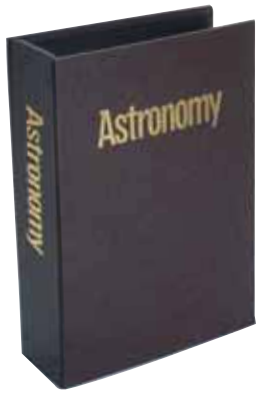


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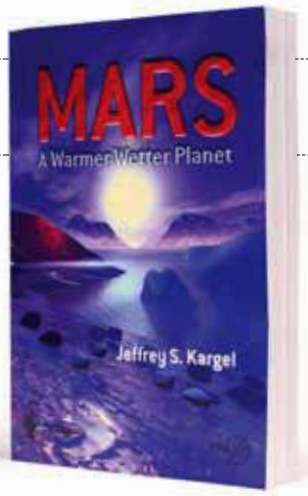
# Arguing for a Mars that's more like Earth




## *Mars: A Warmer Wetter Planet*

Jeffrey S. Kargel, 557 pages, Springer Publishing, New York, 2004; ISBN 1–85233–568–8; paperback, $34.95

Humanity's understanding of Mars has changed dramatically during the past 40 years. As data from spacecraft, both orbiters and landers, poured in, scientists' initial views of a cold, dry planet transitioned to talk of oceans and lakes in the recent martian past. In this book, Jeffrey Kargel, one of the scientists who proposed the "oceans and glaciers" hypothesis for Mars, presents a detailed case for this dramatic new view.

One caution: Appealing as the title may sound, this is no book for the casual reader. Those comfortable with the technical jargon of geology, physics, chemistry, and biology will find the book easygoing; others won't. It also helps to be familiar with martian place names and the planet's overall geography.

Chapters 4 through 7, the core of the book, discuss Kargel's involvement with the University of Arizona group that, in 1989, started presenting evidence for a recent ocean in the northern plains and a large ice sheet covering the southern polar latitudes. (Kargel now works at the Astrogeology Branch of the United States Geological Survey in Flagstaff, Arizona.)

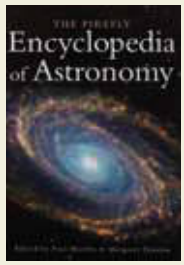
These chapters present detailed geomorphic arguments and evidence for oceans and ice sheets revealed by the Viking, Mars Global Surveyor, and Mars Odyssey spacecraft. Chapter 11 covers recent information from NASA's two Mars Exploration Rovers, Spirit and Opportunity, and the European Space Agency's Mars Express. The text includes results presented at the Lunar and Planetary Science Conference in March 2004.

The book provides a thorough discussion of the subject in the title, and is illustrated with lots of photos showing features (and their terrestrial analogs) that Kargel and his colleagues interpret as indicative of oceans and glaciers. The title is actually a bit misleading because Kargel argues liquid water has existed during only a few transient periods and that most of Mars' geologic evolution involves ice.

There is no lack of references to Kargel's publications on the book's topics, but the work of other scientists, particularly those with opposing viewpoints, receives much less coverage. The book focuses mostly on the visible evidence for action by water and ice. Kargel spends little time detailing how water and ice might cycle through the martian subsurface or in explaining the atmospheric and climatic changes that would follow the appearance of oceans and glacial episodes.

The book contains few typographical errors or errors involving scientific content. The 8-page bibliography is more than adequate for the general reader, but scientific readers would find a more extensive bibliography useful. While photos are generously supplied in a color section in the book's center, illustrations lack figure numbers. They would have made it easier for readers to correlate the text and relevant illustrations.

I recommend this book to those well-versed in Mars studies. Such readers will find it provides an excellent (although somewhat one-sided) summary of the case for a Mars that has seen a lot of action by water and ice. — NADINE BARLOW *is a planetary scientist who has explored the geology of Mars, especially its craters, using spacecraft, for 22 years. She teaches at Northern Arizona University in Flagstaff.*



## *The Firefly Encyclopedia of Astronomy*

Paul Murdin and Margaret Penston, editors, 202 pages, Firefly Books, Buffalo, New York, 2004; ISBN 1–55297–797–8; hardcover, $59.95.

This book contains 350 color photos and 1,750 entries from all areas of astronomy and planetary science. Scattered through the pages are lengthy essays on backyard observing that aim to help readers explore the more accessible subjects covered.

## *Centauri Dreams*

Paul Gilster, 302 pages, Copernicus Books, New York, 2004; ISBN 0–387–00436–X; hardcover, $25.

Paul Gilster is fascinated by interstellar space flight — not the *Star Trek* kind, but the real thing. He takes the reader on a tour of plans being developed quietly at NASA and other space agencies for sending an unmanned probe to Alpha Centauri, the nearest star. Extensive notes capably steer readers into the technical literature. Call this book science-fiction-for-real.

## *Star Lore: Myths, Legends, and Facts*

William Tyler Olcott, 453 pages, Dover Publications, Mineola, New York, 2004; ISBN 0–486–43581–4; paperback, $21.95.

Olcott's book first appeared in 1911 and saw many editions before going out of print. This reprint brings back a delightful collection of skylore. The 54 constellations covered (out of an all-sky total of 88) are those visible from mid-northern latitudes.

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Astronomy magazine

# RESOURCES

Learn more about this issue's topics:

## THE WEIRDEST STAR IN THE SKY

**BOOKS —** Find a detailed account of the discovery of SS 433's strange properties in *The Quest for SS 433* by David H. Clark (New York: Viking Press, 1986). Clark also unravels some of the initial mystery that surrounded this object. It's interesting to compare ideas about SS 433 at the time of its discovery to now.

For a brief history of astrophysics, as well as an entertaining introduction to objects as strange as SS 433, read *Black Holes and Time Warps: Einstein's Outrageous Legacy* by Kip S. Thorne (New York: W. W. Norton & Co., 1994). Thorne takes a difficult subject and makes it understandable.

Another delightful read, which deals with many strange celestial objects, is *Extreme Stars* by James Kaler (New York: Cambridge University Press, 2001). For a review of this book, see pages 99–100 in the January 2002 issue of *Astronomy*.

## DESCENDANTS OF THE DIPPER

**ARTICLES —** There's no better place to find out more about the Ursa Major moving group than in "Stellar Kinematic Groups — A Reexamination of the Membership, Activity, and Age of the Ursa Major Moving Group" by Jeremy King and colleagues (*Astronomical Journal*, April 2003). In this professional paper, the research team compiled the most up-to-date listings of confirmed and possible members of the group. They looked at the latest distance determinations from the Hipparcos satellite as well as new velocity and abundance measurements.

For a look at the science and aesthetics of a more familiar star cluster, check out "Lure of the Pleiades" by Raymond Shubinski (*Astronomy*, January 2005).

## COYNE OF THE REALM

**WEB —** Learn more about Father George Coyne and the Vatican Advanced Technology Telescope at the Vatican Observatory's site, *clavius.as.arizona.edu/vo/R1024/VO.html*.

Discovery Park in Safford, Arizona, the official visitor center for the Mount Graham facilities, hosts tours in summer and early autumn. Get more information at *www.discoverypark.com*.

For more on the Large Binocular Telescope, see "Binocular vision," coauthored by project director John Hill, in the June 2004 Oe*magazine*, a publication of SPIE, the International Society for Optical Engineering. The article is available on-line at *medusa.as.arizona.edu/lbto/news/binoc.pdf*.

## ASK ASTRO

**WEB —** M. Coleman Miller of the University of Maryland has an excellent introduction to neutron stars at *www.astro.umd.edu/~miller/nstar.html*.

For more on Tod Strohmayer's recent work on neutron stars, see *www.gsfc.nasa.gov/topstory/2004/0908nsmatter.html*.

Check out Orbital Sciences Corporation at *www.orbital.com/SpaceLaunch/Minotaur/index.html* to learn how it uses missile components in its boosters.

The Federal Aviation Administration licenses all commercial U.S. launch vehicles and spaceports. See the agency's report "2004 U.S. Commercial Space Transportation Developments and Concepts: Vehicles, Technologies, and Spaceports" at *ast.faa.gov/files/pdf/Book1screen.pdf* for descriptions of launch vehicles both in use and in development.

To learn more about SMART 1's lunar journey, see *www.esa.int/export/SPECIALS/SMART-1/index.html*.

## JOIN THE SEARCH FOR SPACE ROCKS

**BOOKS —** Start learning about asteroids by reading Curtis Peebles' *Asteroids* (Washington: Smithsonian Books, 2000). This book provides a history of asteroid discovery methods and the people involved.

A book whose title says it all is *Asteroid: Earth Destroyer or New Frontier?* by Patricia Barnes-Svarney (New York: Plenum Press, 1996). The author provides details on subjects as varied as close asteroid approaches to the extinction of dinosaurs.

## STRIKING ANCIENT SKIES

**BOOKS —** *The Comet of 44 B.C. and Caesar's Funeral Games* by John T. Ramsey and A. Lewis Licht (Atlanta: Scholars Press, 1997) provides an overview of this bright comet that was visible in the daytime.

Wayne Sayles, founder of *The Celator* — a journal for ancient-coin collectors — wrote a six-volume series starting with *Ancient Coin Collecting* (Iola, Wisconsin: Krause Publications, 1996). The books cover a range of topics and include information on coins from around the world.

**WEB —** For an introduction to historical sky events and how they ended up on certain ancient coins, visit *tjbuggey.ancients.info/astro.html*.

As you build your astronomical coin collection, be sure to check out Michael Molnar's "Revealing the Star of Bethlehem" at *www.eclipse.net/~molnar/index.html*. Here, you'll learn facts about the "Star of Bethlehem" and view a photo gallery featuring ancient coins from Molnar's collection.

## A PLANETARY PIONEER

**WEB —** Find the Association of Lunar and Planetary Observers at *www.lpl.arizona.edu/alpo*. This site contains information on the group's 14 different observing "sections" — from the planets to the Moon to comets to meteorites. You'll also find contact information for each section's coordinator, plus images, data, observing alerts, and numerous links to related astronomy sites and clubs.

Observers of all skill levels are welcome to join, and ALPO offers a training program for newcomers to develop techniques and gain knowledge. Access the program through the main site or visit *www.cometman.net/alpo*.

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| **10" f/5** StarHopper | **499.00** + $79 freight |
| **12" f/5** StarHopper | **849.00** + $129 freight |

## Big right angle finders . . . small prices.

**Antares** 7 x 50mm and 12 x 80mm right angle finders are priced from $79.95 to $184.95. Choose from Celestron black, Meade blue, or gloss white in either standard mirror-image or erect right-reading models that show you the sky the way it appears on star charts. Economical optional quick release mounting brackets are available.

**$184.95**

## Want to read *unbiased* equipment reviews by astronomers like you? Find them at www.cloudynights.com

## A Premier ETX is almost as easy as GPS!

ETX-125PE **$1095**

Each new Premier Series **Meade ETX** 3.5" to 5" Maksutov-Cassegrain has *Level North Technology* to make it easy to align your scope on the sky.

Simply tell the ETX your zip code or location. It levels its optical tube (a full color deep space image decorates the tube), finds North, sets the time, and moves to its alignment stars – *all automatically!* Center the new wide-field red dot finder on the alignment stars and start observing. That's all it takes. Using an ETX is almost as easy as using a GPS system, but a new ETX Premier costs a lot less!

## The Meade LX90-LNT – new scope, old price.

It's not often that you get a significant upgrade to a product without an equally significant price increase. But Meade has just done it with the new LX90-LNT.

The 8" **Meade LX90-LNT** Schmidt-Cassegrain has *Level North Technology* to make aligning your scope on the sky easier than ever. Simply tell it your zip code or location. The scope levels its optical tube, finds North, sets the time, and moves to its first alignment star – *automatically!* Center the red dot finder on the alignment stars (you still get an 8 x 50mm finder), and start observing. It's almost as easy to use as a GPS system, but it costs no more than the previous LX90!

**$1695**

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# Anyone can sell you a telescope. We'll sell you the right telescope.

## 21st century go-to . . . at a 1984 price.

If you fondly remember the original orange-tube C8, the new 8" **Celestron NexStar 8i Special Edition** will bring back the good old days – at a low price that's straight out of the 1980s!

This limited production SCT combines a modern anodized version of Celestron's vintage orange and black paint scheme, the convenience of a go-to computer, and the bright images of Starbright XLT – Celestron's best multicoated optics ever.

The best part? This 21st century telescope is available for less than the price of an 8" Celestron from 1984 that didn't even have a computer.

Telescopes have changed a lot over the past 20 years. But the value and optical performance of a Celestron C8 have always been standards you can rely on.

**$1399**

## End the fumbling when you set up your scope.

**$49.95**

Setting up your Celestron NexStar or Meade LX200 in the dark can be tricky. It's difficult to line up the mounting holes in the telescope and tripod if you can't see them.

The **Landing Pad**, above, and the **Astroplate**, right, make the job easier. These aluminum plates bolt to your tripod. They have guides that center your scope to line up the mounting holes precisely. The Landing Pad works with 8" to 11" altazimuth NexStars. The Astroplate works with 7" through 14" altazimuth LX200s. It has a built-in level and is also designed to hold your Autostar hand control and up to 11 eyepieces.

**$99**

## *This month's hot new products . . .*

## William Optics ZenithStar refractors starting at $295.

The **William Optics ZenithStar 66** is available in two versions. One is an f/6.2 four-element semi-apo refractor at **$295**, shown below. The second is a three-element f/7 apochromat at **$485**. Each has a 66mm aperture optical system with a 1.25" rack and pinion focuser, a 1.25" 45° viewing angle image-erecting diagonal, a 20mm wide angle eyepiece, a retractable self-storing lens shade, and a soft carry bag. Each has a removable L-shaped mounting shoe that mounts on either a photo tripod or an SCT piggyback. Either can be used as a super finder for your main scope or as a second scope for spur-of-the-moment astronomy, travel, or birding.

**$295**

William Optics ZenithStar 66mm semi-apo

William Optics ZenithStar 80mm semi-apo

**$449**

The **ZenithStar 80** above is a semi-apochromatic doublet at **$449**. It has an 80mm f/6 optical system with a 2" rack and pinion focuser, a 97% reflectivity *silver-coated* 2" star diagonal with a 1.25" eyepiece adapter, a retractable self-storing lens shade, and a soft carry bag. Like the 66mm, it also has an L-shaped removable mounting shoe that will fit a camera tripod or piggyback.

## We actually stock TeleVue.

NP-101 **$3595**

If you want to keep TeleVue customers happy, you have to keep a lot of TeleVue in stock so you can ship fast. We *do* keep a big inventory on hand, so our customers are *very* happy. Others may *say* they carry TeleVue, *but we actually keep TeleVue in stock.* Lots of it.

Here are a few of the TeleVue refractors we stock for immediate shipment.

**TV-60,** 2.4" f/6 apo ..... **$795.00**
**TV-76,** 3" f/6.3 apo ..... **1275.00**
**TV-85,** 3.35" f/7 apo ..... **1680.00**
**TV-102,** 4" f/8.6 apo ..... **2200.00**

All of these refractors are basic optical tubes, with dust covers and a carrying case only. Complete optical tubes, with a star diagonal, Plössl eyepiece, mounting ring, dust covers, and carry case are also available from stock.

## Does your dealer?

As for accessories, we keep them all. Whatever you need – a Gibraltar, Panoramic, or Tele-Pod mount; a Sky Tour computer for your mount; a Nagler, Radian, Panoptic, or Plössl eyepiece; a Powermate or Barlow; an Everbrite 99% reflectivity dielectric star diagonal; a light pollution filter; or a BinoVue – if it's from TeleVue, we probably have it in stock.

## There's nothing mysterious about *this* Sphinx.

**Vixen Sphinx** telescopes and mounts take the mystery out of go-to astronomy. You don't have to know Messier, NGC, or IC numbers to find things in the sky.

Simply move a cross-hair cursor over an object displayed on the 4096-color LCD star chart screen of the Sphinx Star Book hand control. Push a button and the Sphinx mount moves your scope to the object. Zoom buttons on the chart display control the motor speed. Zoom in on an object on the screen and the motors slow for more accurate control. Zoom out and the motors speed up to cover large distances more quickly.

Vixen Star Book hand control showing star chart display

You can update the Star Book's 4MB flash ROM memory from the Internet to keep you current with the heavens. And the easy-to-use Star Book can be used as a stand-alone star atlas so you can learn the skies anywhere, anytime.

**$3250**
ED80SWT-SXW
3.1" f/9 ED apo
Vixen refractor on Sphinx go-to mount

The Sphinx go-to mount with Star Book controller is available separately for use with your own optics. It is also available in premium Vixen telescope/mount packages that range from a 3.1" refractor to big 8" reflectors and catadioptrics.

Vixen Sphinx details and prices are on our **www.astronomics.com** website.

## Meade Deep Sky Imager (DSI) for $299.

The **Meade Deep Sky Imager** takes color deep sky photos at a fraction the cost of a CCD camera. Use it with any scope to take photos of galaxies, nebulas, and star clusters – plus the Moon and planets.

The easy-to-use Meade Deep Sky Imager includes the Autostar Software Suite of planetarium and imaging control software and the USB cables needed to connect the imager to your laptop computer or PC. Best of all, the entire package is all yours for only $299!

# and a website for scopes under $500 at www.first-telescope.com!

Our new website is just the thing for beginning astronomers looking for maximum performance at minimum cost. We have the best brand name telescopes – and microscopes, too – all budget priced for less than $500 . . . but worth more!

## Celestron 11" scopes start at only $1699.

The 11" Celestron **Advanced Series** Schmidt-Cassegrains make big aperture astronomy affordable. With almost twice the light-gathering of an 8" scope, an 11" shows you more deep space wonders than an 8" – *for about the same price.*

The 11" Advanced Series telescopes available from our stock include:

C11S on an equatorial mount ..... **$1699.00**
C11S with XLT coatings ..... **1979.00**
C11S-GT go-to equatorial ..... **1999.00**
C11S-GT go-to with XLT coatings ..... **2279.00**

The C11S and C11S (XLT) have a German equatorial mount, adjustable height tripod with 2" steel legs, slow motion controls, setting circles, 40mm Plössl eyepiece, and 9 x 50mm finder. Starbright multicoatings are standard on the C11S. XLT multicoatings on the C11S (XLT) give you 16% more light. An optional dual-axis drive is available.

The C11S-GT and GT (XLT) go-to models add dual motor drives and a NexStar computer to automatically find over 45,000 stars and objects for you.

At only 29 lbs for the heaviest piece, they are easy to transport and set up. And, best of all, they are very affordable. A big scope no longer costs a fortune, thanks to Celestron.

11" Celestron C11S

**$1699**

## Celestron's NexImage captures the solar system for only $99.

There's a true CCD at the heart of the **Celestron NexImage** Solar System Imager. It's a Sony HAD full color 640 x 480 CCD with 5.4 micron pixels. It takes high power lunar/planetary images with any brand or size telescope and sends them to your computer to view live or print out later. At only $99, it makes serious solar system imaging affordable for everyone.

## Some nifty accessories to make your observing easier.

Red night vision flashlights protect your dark-adapted vision while you're observing. **Celestron's** variable brightness flashlight (our part #VLED) is **$21.95**.

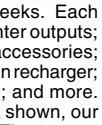
The **Rigel Systems** variable brightness light (#4591) shown is **$24.95**. Rigel's 2-color variable brightness light (#4592) – red for reading star charts, and blue-white for setting up and taking down your scope – is **$29.95**.

Put vibration suppression pads under the legs of your telescope or spotting scope tripod and you'll virtually end the tremors that blur your view for a few seconds each time a breeze comes up or you touch the scope to focus.

A set of three **Celestron** pads, our part #VSP, costs **$49.50.** The **Meade** #895 pads to the right cost **$49.95.** Both sets dramatically improve your observing and are well worth their low cost.

**Celestron Power Tank** rechargeable 12-volt batteries have the power you need to run your telescope and accessories all night long. They can be recharged hundreds of times, saving you big bucks over the cost of buying flashlight batteries every few weeks. Each has *two* 12V DC cigarette lighter outputs; 3, 6, and 9V DC outputs for accessories; an emergency spotlight; built-in recharger; shoulder strap; carry handle; and more. The 7 amp hour Power Tank shown, our part #4512V, is only **$59.95**. The 17 amp hour Power Tank, our #4517V, is sale priced at only **$89.95**.

Leave out the fancy boxes and engraved barrels, but leave in the performance. What do you get? Very good quality **Burgess Optical** 1.25" wide angle eyepieces for only **$49**. They're priced to be a super choice for binoviewers. Available in a 60° field 8mm or 12mm, a 65° field 17mm, and a 67° field 21mm.



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04.16.05

# The theme for AstroDay 2005 in Hilo,

Hawaii, is "Bringing Astronomy to the People." If this year's celebration is like previous years', the organizers will be successful in this promise. Last year, the event drew more than 12,000 people. ◖ Astronomy Day is part of a worldwide

MALLRATS AND ASTRONOMERS made strange bedfellows at AstroDay 2004 in Prince Kuhio Plaza in Hilo, Hawaii. Shoppers' interests were piqued by the astronomy displays around the mall. TETSUHARU FUSE

celebration created by the Astronomical League. This event in Hawaii is one of many held annually on the Saturday closest to the First Quarter Moon falling between mid-April and mid-May. What makes the Hawaiian gathering so popular?

Location is the primary influence. Each year, AstroDay is held at Prince Kuhio Plaza, a mall in Hilo. Combine shopping with a Saturday, and you have the makings for a large crowd.

While some attend for the commercial aspect of the mall, AstroDay converts many attendees from shoppers to astro-enthusiasts. Gary Fujihara, the coordinator of the event, believes the day is particularly successful in sparking an interest in young people.

"Some children visit the mall out of boredom, looking for something to do," explains Fujihara. "We show them the fun and magic of astronomy, and they leave Prince Kuhio with a growing appetite for exploring the night sky."

For more information, e-mail Gary Fujihara at fujmon@mac.com; web site, *www.astroday.net*.

03.05.05

## Tri Star

Guilford Technical Community College, Jamestown, North Carolina. Cosponsored by the Cline Observatory and Greensboro Astronomy Club, this event features speakers, displays, prizes, workshops, and vendors. For more information, e-mail, Tom English at trenglish@gtcc.edu; web site, *technet.gtcc.cc.nc.us/comserv/cline*.

03.10.05–03.12.05

## Mid-Florida Star Gaze

Kye Ewing's Star Farm, near Venus, Florida. The Astronomical Society of the Palm Beaches will host this sixth-annual event. The site is based away from light pollution, high winds, sand, and the salty ocean spray. For more information, visit *www.palmbeachastro.org*.

03.11.05–03.13.05

## All Arizona Messier Marathon

Farnsworth Ranch, Arizona City, Arizona. Hosted by the Saguaro Astronomy Club, this popular event tests the mettle of dedicated astronomers, who rush to find all 110 Messier objects during the weekend. A great horizon and dark skies ensure a lively competition. For more information, visit *www.saguaroastro.org*.

03.14.05–03.18.05

## Lunar and Planetary Science Conference

South Shore Resort and Conference Center, League City, Texas. This conference showcases the latest research in planetary science. *Astronomy* senior editor Robert Burnham will attend. For more information, visit *www.lpi.usra.edu/meetings*.

03.26.05–03.27.05

## Kitt Peak National Observatory CCD Workshops

National Optical Astronomy Observatory Headquarters, Tucson, Arizona. Learn how to produce stunning images of deep-sky objects. These workshops cover many topics, including basic equipment setup, problem solving, and obtaining the best possible results. For more information, call Robert Wilson at 520.318.8440; e-mail, rwilson@noao.edu; web site, *www.noao.com*.

04.06.05–04.08.05

## International Dark-Sky Association Annual Meeting

Hilton Hotel, Tucson, Arizona. This year's gathering will concentrate on"Vision at Night." Participants will discuss light-pollution issues, including human health and ecology. For more information, e-mail, ida@darkskyorg; web site, *www.darksky.org*.

04.06.05–04.09.05

## Mid-South Star Gaze

Rainwater Observatory, near French Camp, Mississippi. Designed for anyone interested in astronomy, this event will feature lectures and informal observing sessions. For more information, visit, *www.rainwaterobservatory.org/stargaze*.

04.08.05–04.10.05

## Spring Equinox Star Party

Kelling Heath, Norfolk, United Kingdom. This event is held at a particularly dry site for the region. When not observing, you can visit one of the many museums in greater Norfolk. For more information, visit *www.starparty.org*.

04.16.05–04.17.05

## Northeast Astronomy Forum and Telescope Show

Rockland Community College, Suffern, New York. This annual gathering features observing, workshops, lectures, and many exhibits. For more information, visit *www.rocklandastronomy.com*.

04.22.05–04.23.05

## NIAGfest

Camp Crosley, North Webster, Indiana. Cosponsored by the Northern Indiana Astronomical Group and the Great Lakes Region Astronomical League, NIAGfest is a weekend of camping and observing. For more information, e-mail sstephan@kconline.com; web site, *www.clubs.kconline.com/was/niag.htm*.

05.04.05–05.08.05

## Desert Sunset Star Party

Caballo Loco Ranch RV Park, near Tucson, Arizona. The Whipple Observatory will offer a day-long tour on the Friday during the star party. Pima Air and Space Museum, Kitt Peak National Observatory, and other nearby astronomical sites provide alternatives to observing. For more information, visit *chartmarker.tripod.com/sunset.htm*.

**CONTACT INFORMATION**

Please submit club announcements 4 months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Also use this e-mail address to submit your events for our on-line calendar.

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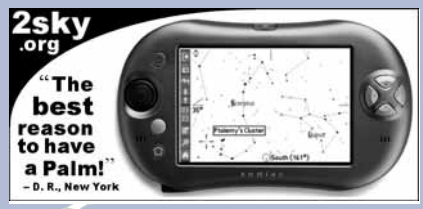


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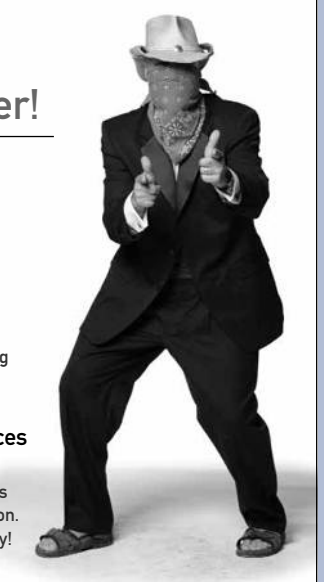
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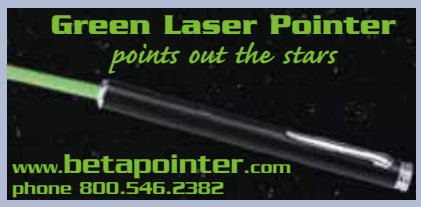
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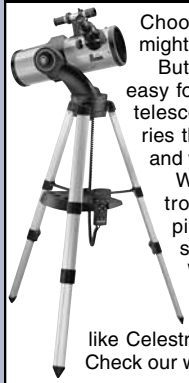

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# Reader gallery

## Readers share their images...

Lunar-eclipse parade /// The Small Magellanic Cloud and NGC 104
The Pac-Man Nebula /// Conjunction of Venus and Regulus /// Neptune and Triton

WORLD-SERIES ECLIPSE

## The Moon turns orange

The total eclipse of the Moon October 27/28, 2004, was viewed by millions throughout North and South America and parts of Europe. Observers reported a bright, reddish-orange Moon during totality. Because light falling on the totally eclipsed Moon is scattered by our atmosphere, lunar eclipses are brighter when Earth's atmosphere is clean, and darker when the air is filled with particulates. The particles are more numerous following volcanic eruptions. Another fun fact: This was the first lunar eclipse to occur during a World Series baseball game.

ECLIPSE TRIPLE-PLAY (10-inch Meade LX200 Schmidt-Cassegrain telescope at f/4, Canon EOS 300D digital SLR camera, exposures ranged from 1/250 second to 10 seconds, taken October 27/28, 2004, from St-Liboire, Quebec)
/// MARTIN BERNIER

*Top,* SHADOW TRACKS (3.2-inch Stellarvue AT1010 Nighthawk apochromatic refractor at f/6, Nikon D70 digital camera, 1/1,250- to 1/8-second exposures, taken October 27, 2004, from Branford, Connecticut) /// JIM McKAY

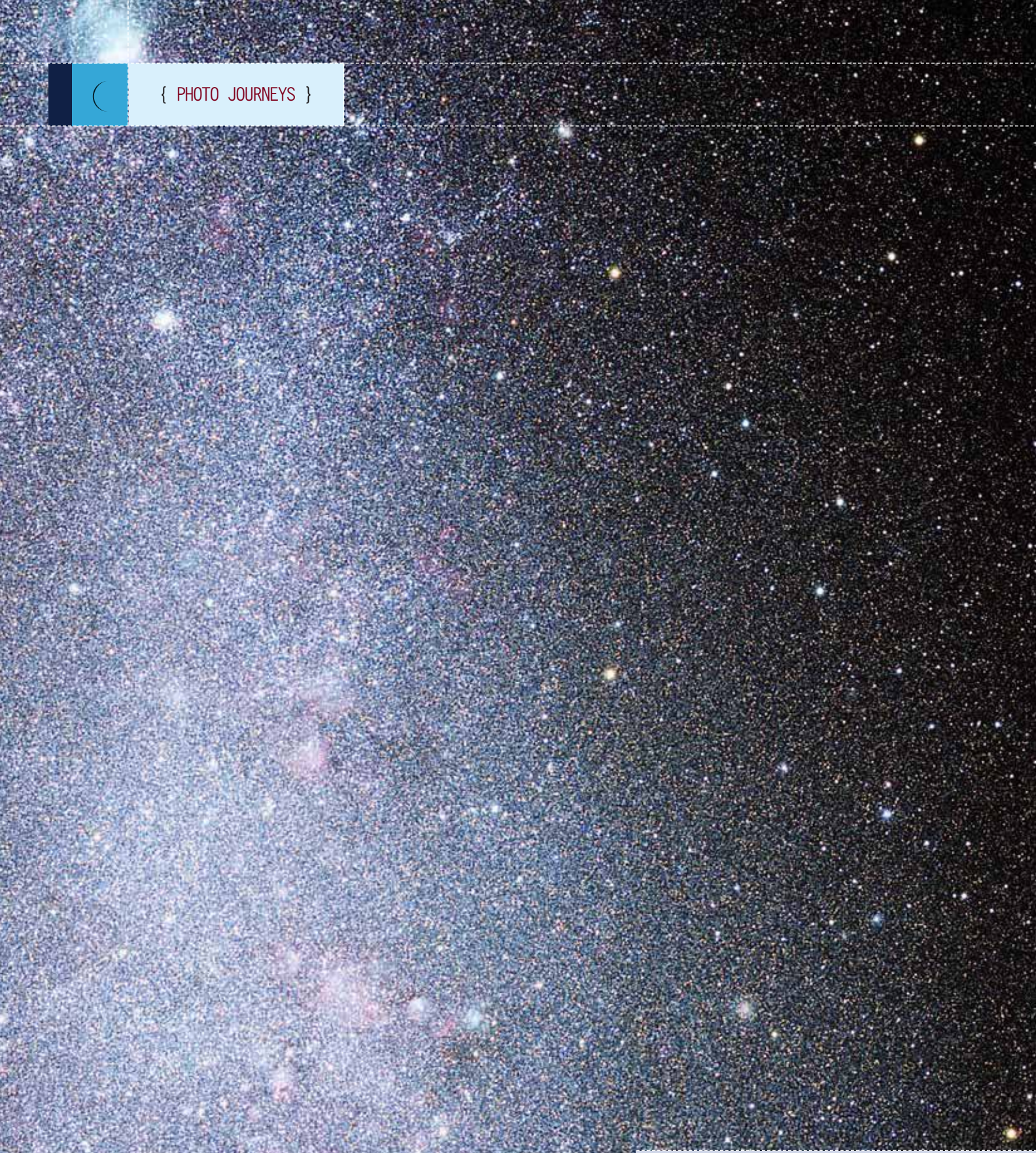
*Center,* THE ECLIPSED MOON (4-inch Vixen achromatic refractor at f/10, Canon EOS Rebel digital SLR camera at ISO 800, 10-second exposure taken October 28, 2004, at 3h05m UT from Smithtown, New York) /// PHIL HARRINGTON

*Bottom,* MOON WITH PLEIADES AND DOME (Canon D20 digital camera with a 28mm lens at f/3.5, ISO 800, 15-second exposure, taken October 27, 2004, from Club IO Observatory, Val Belair, Quebec) /// JAY OUELLET

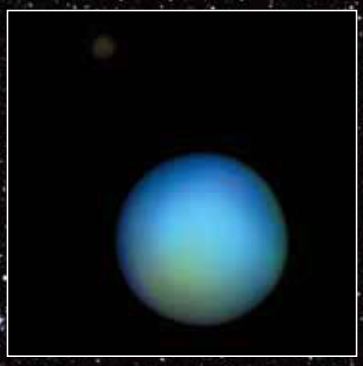
Send your photos to: ASTRONOMY reader gallery, P.O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com.
Please include your full name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.

*Center,* THE WHOLE SHEBANG (6-inch Takahashi FCT-150 apochromatic refractor at f/7, Canon 10D digital SLR camera, exposures ranged from 1/250-second to 10 seconds, taken between 1h00m UT and 4h30m UT October 28, 2004) /// RANDY BREWER

*Bottom,* A COLORFUL ECLIPSE (Canon EOS Rebel digital camera, tripod-mounted with a 500mm lens at f/6.3, ISO 100, 1/500- to 8-second exposures, taken October 27, 2004, from Quebec City) /// PHILIPPE MOUSSETTE



THE SMALL MAGELLANIC CLOUD AND NGC 104 (4-inch Astro-Physics Traveler AP105EDF apochromatic refractor at f/5.9, SBIG STL-11000 CCD camera, LRGB image with exposures of 70, 40, 40, and 40 minutes, respectively, taken from Observatorio Antilhue, Chile)
/// DANIEL VERSCHATSE



*Top left,* THE PAC-MAN NEBULA (NGC 281) (8-inch Celestron Schmidt-Cassegrain telescope at f/6.3, Starlight Xpress SXVH9 CCD camera, Hα/RGB image with exposures of 160, 20, 20, and 20 minutes, respectively) /// WOLFGANG PROMPER

*Bottom,* CONJUNCTION OF VENUS AND REGULUS (Tripod-mounted Nikon D100 digital SLR camera, Nikon 300mm lens at f/6.3, ISO 800, 0.6-second exposure taken at 5:32 A.M. PST October 3, 2004, from Rocky Hill Observatory, Sonoma Mountain, California) /// TIMOTHY FERRIS

*Top right,* NEPTUNE AND TRITON (6-inch Astro-Physics 155 EDF apochromatic refractor at f/26, Baader Fluorite Flatfield Converter Barlow lens, Canon EOS Rebel 10D digital SLR camera,100 individual frames combined, taken October 20, 2004, from Rossville, Tennessee) /// RONNIE WARNER

NGC 4935 (16-inch RC Optical Systems Ritchey-Chrétien telescope at f/8.4, SBIG ST10-XME CCD camera, LRGB image with exposures of 90, 20, 20, and 20 minutes, respectively) /// STEVE MANDEL AND ADAM BLOCK

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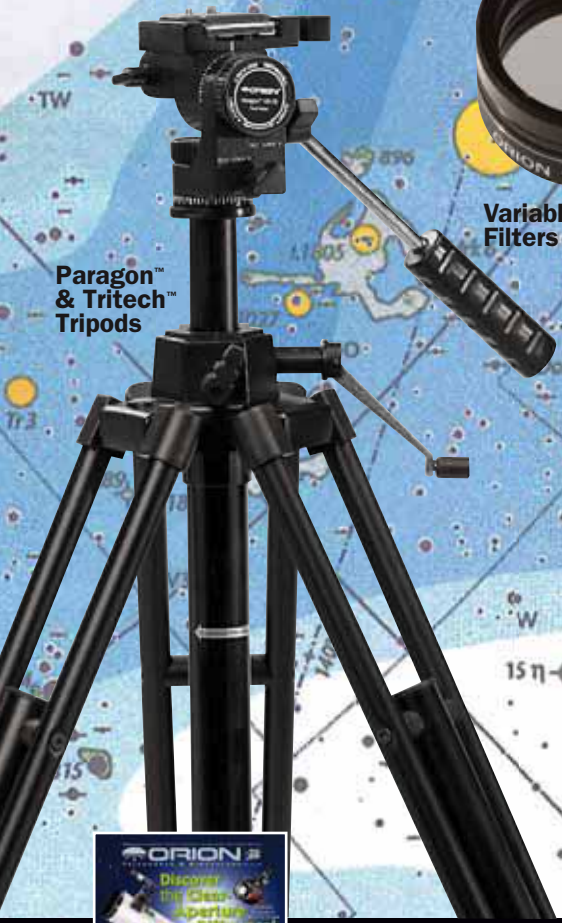

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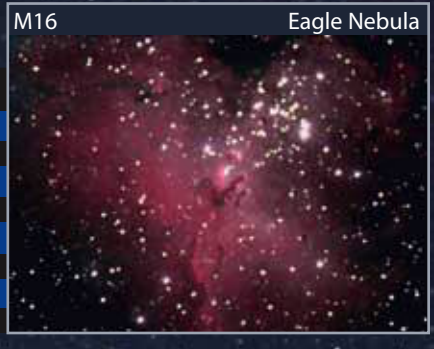
M16 Eagle Nebula



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